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SARCOMATOUS TUMORS OF THE TESTICLE[1]

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IN a recent monograph (13) I emphasized the confusion that had existed for many years with regard to the nature of round cell tumors of the testicle. For long it was stated in many textbooks that sarcoma was the commonest tumor of this organ and that it was a peculiar exception to sarcomatous tumors in general in that it produced metastases in the lymphatic glands. As pathological observations accumulated and these tumors were studied in greater detail, it was found that many testicular tumors were in reality teratomatous in nature. The pioneer work of Wilms (49), Pick (39), Chevassu (7), and Nicholson (36) among others showed that about 50 per cent of these tumors contained derivatives of one or all of the three primary germinal layers, although derivatives of any one of these layers could grow in excess and produce what at first glance seemed to be a homogeneous tumor. Another important fact was recognized, i.e., that any of the derivatives could undergo malignant change with the production of a carcinoma or a sarcoma, the development of a carcinoma from the hypoblastic elements being most frequently seen. Various writers including Waldeyer (47), Breus (4), Malassez (30), Carnot and Marie (5) had described peculiar testicular tumors which characteristically showed invasion of the veins with the formation of an intravascular growth, sometimes extending through the vena cava to the heart. The French authors called these "sarcome angioplastique." Wlassow (50) and Schlagenhaufer (43) first pointed out the now well recognized fact that these are in reality carcinoma, the majority being chorionic in type.

The other common tumors of the testicle are soft homogeneous growths resembling sarcomata both microscopically and macroscopically and on account of the variability in the size and arrangement of the cells, they were often regarded as such. Ehrendorfer (17) and Krompecher (29) regarded many of them as alveolar sarcomata, other observers classed them as endotheliomata, but Kocher and Langhans (26) first suggested that the majority were carcinomata and that their method of producing metastasis in lymph glands was not surprising. Later Chevassu (8), Nicholson (37), Ewing (18), Dew (14), and Bell (2) among others emphasized the essential distinction between these growths and the sarcomata. It is conceded by the majority of observers that they are derived from the cells of the seminal epithelium, and Chevassu has coined the appropriate name "seminome" for them. While recognizing their undoubted carcinomatous nature, Ewing (18) classified them as "embryonal carcinomata" and regarded them as a one-sided development of a teratoma.

The writer (14) has reviewed this problem elsewhere and has brought forward conclusive evidence in favor of the view that they are

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Fig. 1. Teratogenous sarcoma of testicle showing homogeneous cellular areas, areas of softening and diffuse hæmorrhage. Case 1.

both histogenetically and clinically a group distinct from the teratogenous growths. They are as a rule composed of comparatively large cells with hyperchromatic nuclei and little cytoplasm and their stroma is often infiltrated with small lymphocytes. There is no doubt that, taking histological appearances into consideration, there may be great difficulty in distinguishing many of them from the sarcomata. Bell (2) who upholds the view that they are derived from the seminal epithelium has recently emphasized this diagnostic difficulty and in spite of their epithelial origin has adopted the term, "carcino-sarcoma" for those which histologically show a sarcomatous appearance. He states that "this feature is probably related to the mesothelial origin of the seminal cells and to reversionary tendencies." It would seem that even histologically the carcinomatous characteristics predominate and that as their pathological and clinical behavior is carcinomatous, their histological variations should not be overemphasized. The term "carcino-sarcoma" is an unnecessary and a somewhat confusing addition to an otherwise overburdened nomenclature. For a similar reason the term "mesothelioma," introduced by Adami (1) has never gained acceptance.

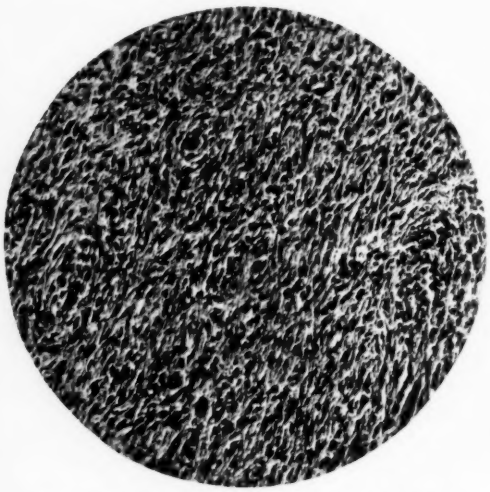

Fig. 2. Section of typical area of tumor of Case 1, showing spindle cell sarcoma. × 110.

If both these groups of tumors are excluded, it will be found that only about 2 per cent of testicular tumors can be regarded as primary sarcomata. True sarcomata, however, do occur and the previously unreported cases here recorded illustrate the various pathological types.

The sarcomatous tumors arise from the following tissues: (1) the mesoblastic elements of a teratoma; (2) the intertubular connective tissue of the testis and epididymis; (3) the coverings of the testis and the spermatic cord; (4) blood or lymph borne metastatic emboli.

TERATOGENOUS SARCOMATA

The mesoblastic elements of teratogenous tumors give rise to the varied cellular stroma

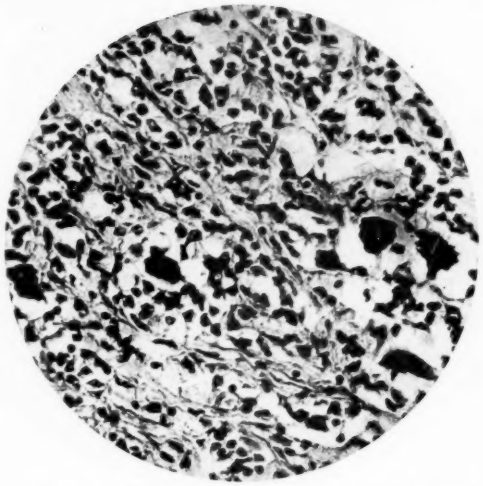

Fig. 3. Section of one portion of tumor, Case 1, showing giant cells. × 360.

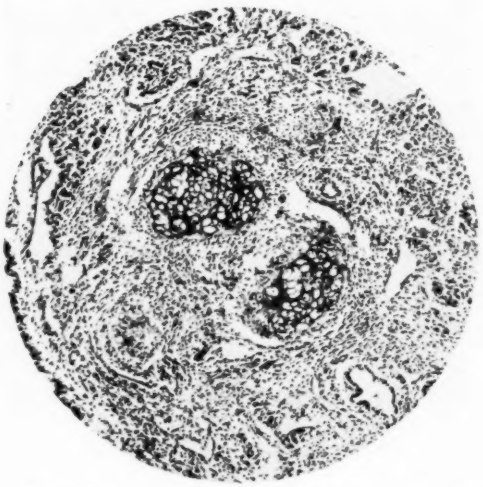

Fig. 4. Section, Case 1, showing teratomatous elements, cartilage, and the formation of "glandular acini."

of these growths. This in many cases retains a strikingly embryonic appearance so that the diagnosis of mixed sarcomatous tumors so common in the older records is not surprising. Other types of tissues, such as cartilage, striped or unstriped muscle, lymphatic, myxomatous or lipomatous tissue may occur and their occurrence in various proportions has given rise to the diagnosis of many types of tumor, their name depending on the predominating tissue present. It is now recognized that the presence of any heterogenous tissue in a testicular neoplasm is presumptive evidence of the teratogenous nature of such a growth. Malignant change in any of these mesoblastic derivatives with the production of various types of sarcomata is rare but has been recorded. There seems no doubt that many of the cases of spindle cell sarcoma of the testis described by earlier observers were in reality teratogenous, this fact being unrecognized in most cases because sections from all parts of the tumor were not examined. This appears to be so in the cases recorded by Kocher and Langhans (26), Ehrendorfer (17), Monod and Terillon (34) and Debarnardi (12). In examining an old museum specimen labelled plexiform spindle cell sarcoma, Wilms (49) found cysts lined with squamous and columnar epithelium and areas of cartilage, thus proving its teratogenous nature. Ewing (18) is particularly insistent that great care must be exercised in spindle cell growths to exclude myomatous or other elements derived from a teratoma.

Case 1 illustrates some of the points.

Case 1. Teratogenous spindle cell sarcoma. H. K., aged 29 years, gave a history that 8 months before admission he had injured the left testicle which became tender and swollen. It subsided somewhat under treatment by counter irritation, but after a month he noticed that it was slowly enlarging. This enlargement had become more noticeable during the last 2 months. He had had no pain since the accident and otherwise felt well. Examination revealed a large pyriform tumor extending to the external abdominal ring. The veins of the scrotum were very large, but the skin was freely movable over the mass. Neither the testicle nor the epididymis could be differentiated: no testicular sensation was elicited. The tumor was opaque to transillumination. The other testicle appeared normal. Palpation in the epigastric region revealed nothing abnormal. The other organs appeared healthy, and he stated that he felt well and had not lost any weight. Operation was advised and the radical operation for teratoma testis was carried out, no enlarged glands, however, being discovered in the lumbar region, although on account of the amount of retroperitoneal fat present a perfectly clean dissection was impossible. Four months later the patient returned complaining of shortness of breath, loss of weight and

Fig. 5. Teratogenous liposarcoma of testicle. Case 2. Note upper half of lipomatous nature, lower half consisting of two large nodules of fibrosarcomatous growth with some hæmorrhage, caseation, and cavitation. One-half natural size, weight 12 pounds.

strength, and severe radiating pains in the epigastric region. Examination revealed scattered signs in both lungs and a right-sided pleural effusion, which on being tapped contained blood. A small mass was palpable in the epigastric region.

A fortnight later the patient reported that he had lost another 14 pounds of weight, and on examination the liver was found to be enlarged. There were many enlarged superficial abdominal veins and some œdema of the feet. The patient died 23 weeks after the operation from cachexia and exhaustion.

Pathology. The tumor was oval in shape, measuring 10 centimeters by 5 centimeters in its longest diameters. It was vascular, the upper two-thirds being composed of a pink homogeneous tissue, the lower portion showing areas of diffuse hæmorrhage, softening, and myxomatous change (Fig. 1). Neither the testis nor the epididymis could be differentiated. The tunica vaginalis contained no fluid but was adherent in many places, although the growth had not

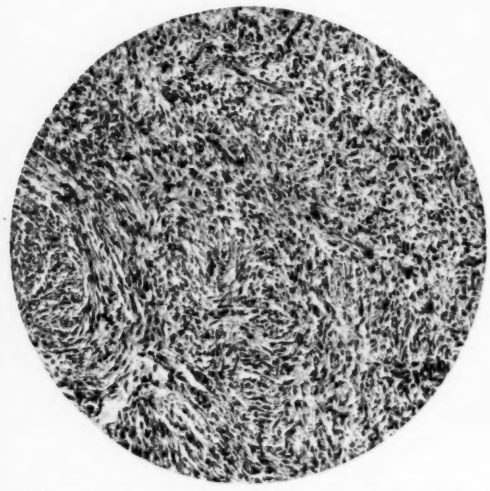

Fig. 6. Section of tumor from Case 2 showing typical areas of fibrosarcoma. × 75.

perforated into the cavity. The cord showed some hypertrophy and was slightly infiltrated with new-growth in its lowest part. The surrounding scrotal tissues were not invaded. There were no hard areas, no cysts, nor any suggestion that it contained teratomatous elements.

Microscopically. Sections were taken from various portions of the cut surface and examined microscopically. It was found that the greater part of the tumor was composed of homogeneous spindle cell sarcomatous tissue (Fig. 2). In this the cells were arranged in a diffuse irregular manner and in whorls, and were embedded in a fine intercellular matrix. In parts, the cells were in intimate relationship with blood vessels, many of which appeared simply as chinks in the neoplastic tissue. The nuclei were hyperchromatic, variable in size and staining reactions, and mitotic figures were not uncommon. Scattered irregularly throughout the tumors were giant cells with two to four centrally placed nuclei, resembling closely those seen in many typical spindle cell sarcoma of other tissues (Fig. 3).

Large areas of necrosis with degeneration, central breaking down and here and there survival of neoplastic cells around blood vessels, hæmorrhagic areas and islets of myxomatous tissue were present in some sections. There could be no doubt as to the sarcomatous nature of the greater part of the tumor. Further search revealed, however, teratogenous elements in some of the sections. These took the form of striped and unstriped muscle fibers, fetal and adult cartilage, myxomatous areas, and a few cysts lined with low epithelium in some cases filled with mucoid material (Fig. 4). A careful review of all the sections showed no evidence of any carcinomatous tissue.

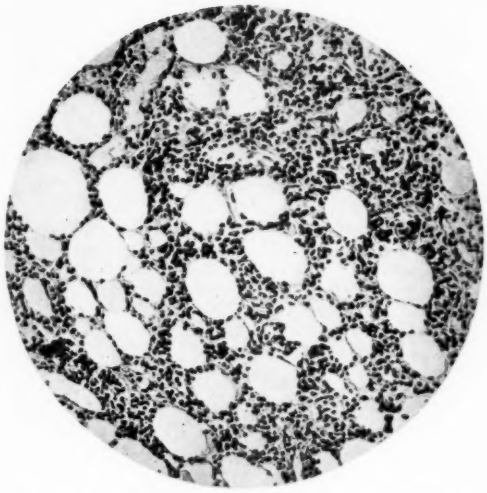

Fig. 7. Section of tumor in Case 2, showing invasion of fat by sarcomatous cells. × 115.

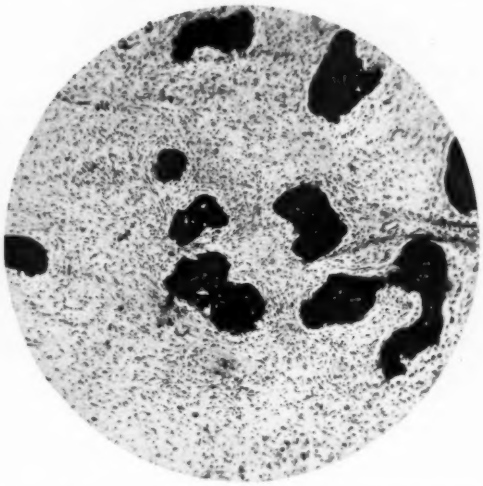

Fig. 8. Section from tumor, Case 2, showing area of calcified cartilage. × 50.

Nature of the tumor. The tumor is certainly an example of sarcoma developing in a teratoma. The presence of giant cells among the spindle cells in sarcomatous tumors of the testis has been referred to by Benenati (3), Debarnardi (12), and Chevassu (7) and as pointed out by Ewing (18) suggests an origin from muscle fibers. This tumor almost certainly originated in this way since it contained scattered bundles of muscle fibers, and in certain areas transitions between these and spindle cells. Unfortunately, the metastases could not be examined. The presence of blood-stained pleural effusion, the rapid development, and the pulmonary signs indicate that multiple metastases existed in the lungs. It is almost certain that these would have been found to be composed of pure spindle cell tissue. The appearance of an epigastric secondary glandular mass is of great interest. It may be that these glandular metastases were also of the same sarcomatous nature, or it may be that, as in some of the reported teratogenous cases, mixed or carcinomatous secondaries were also present. The absence of carcinomatous change in the numerous sections of the primary tumor does not favor the latter view.

The following is a record of a somewhat similar neoplasm.

CASE 2. Teratogenous lipofibrosarcoma. C. H., aged 67 years, was under the care of Dr. F. Grutzner, to whom I am indebted for the case history and the specimens. Twenty years before being seen he had had an attack of mumps, which was complicated by bilateral orchitis which subsided. Since then he had had no children but the uninvolved testicle showed no sign of atrophy. Seven years before seeking advice, his right testicle began to enlarge and he thought that he had a rupture. This swelling had gradually increased but during the latter 12 months had grown much more rapidly, particularly during the last 3 months. There had never been any trauma to the organ, pain had never been present, and in spite of the great size and weight of the tumor, he had been able to carry out his occupation of orchardist. He presented himself for examination because of the discomfort from dragging in the loin and the deformity produced by the tumor. When first examined he appeared to be in normal health, the large swelling of the right half of the scrotum being the only abnormality detected. The swelling of the right scrotum was very large, extending to the knee, pyriform in shape, and of a solid consistency. The scrotal skin was smooth, not adherent, but there was some chafing with mild local infection on the anterolateral aspect. The tumor was hard, regular in the upper part, but somewhat nodular below. Neither the testis nor the epididymis could be differentiated and as the swelling extended into the inguinal canal, the cord could not be well examined. There was no testicular sensation present and the mass was opaque to transillumination. No enlargement of the lumbar or inguinal lymphatic glands was detected. The diagnosis of neoplasm was made and operation

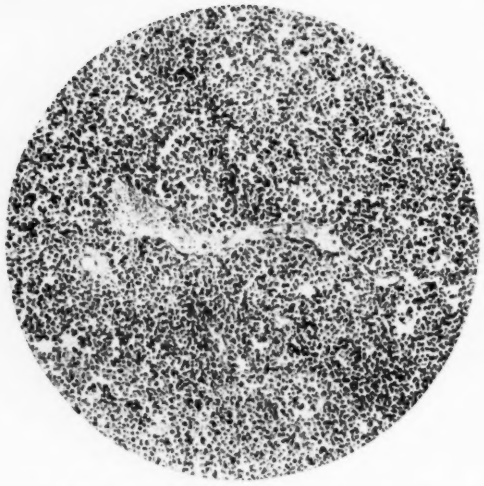

Fig. 9. Primary lymphosarcoma of the testis. × 135.

advised. This was performed on November 18, 1924, an orchidectomy with high division of the cord being successfully carried out. Seven months later the patient returned with a small hard tumor just beyond the outer edge of the operation incision, near the anterior superior iliac spine. This lump grew rapidly and when as large as a tennis ball ulcerated through the skin, which, however, was not infiltrated. The appearance exactly resembled a typical ulcerating sarcoma. A mass then appeared over the os pubis and rapidly extended into the perineum, eroding and displacing the bones of the pubis and ultimately reaching the size of a cricket ball. The ulcerated area in the groin became infected and a spreading cellulitis of the abdominal wall developed. The patient died of sepsis and exhaustion 9 months after the original operation. At no time was there any evidence of glandular or visceral metastases, the recurrence appearing to be wholly local. At autopsy no evidence of any metastasis could be discovered either in the lumbar glands or in the viscera.

Pathology. The tumor was the largest testicular tumor that I have seen, measuring 25 centimeters by 12 centimeters and weighing 12 pounds in the fresh state (Fig. 5). It was pyriform in shape, and on section was found to contain fibrofatty tissue in the upper half and two large nodules of firm, tough growth in the lower half. Neither the testicle nor the epididymis could be differentiated by dissection. The tunica vaginalis was thickened, in the main obliterated by adhesions, so that no fluid was present. The fibrolipomatous tissue extended into the cord and was composed of typical lobulated lipomatous tissue with some areas of recent hæmorrhage. Sections taken from the lower portion showed some isolated cellular areas of embryonic fatty tissue, suggestive of liposarcoma. The two large lobules in the lower portion of the tumor were sectioned, over 80 blocks being cut and examined. These revealed a cellular growth composed almost entirely of fibroblastic spindle cells, set in a hyaline intercellular matrix, resembling in every way a pure fibrosarcoma (Fig. 6). There were many areas of degeneration and caseation with the survival of neoplastic cells around blood vessels, and here and there areas of cavitation and hæmorrhage.

In some of the sections, definite mixtures of lipomatous and myxomatous tissue with the fine spindle cell sarcomatous growth were seen (Fig. 7), but nothing was found in the first fifty sections that could be regarded as evidence of the teratogencus nature of the growth. Sections of the recurrence of the growth showed a simple spindle cell sarcoma rather more active in appearance than the primary growth.

Nature of the tumor. For some time it was difficult to decide in what catagory to place this tumor. The following suggestions were considered:

1. The tumor was an example of a liposarcoma originating in the fibrofatty testis such as sometimes results after orchitis due to mumps. Curling (11) and Smith (44) among others have referred to the total replacement of a testis by such fibrofatty tissue. As has been pointed out recently by McGuines (32), liposarcomata not infrequently develop in such pathological organs. There was in this case no evidence of previous testicular atrophy, while the great size, the lack of homogeneity in the tumor, and the type of sarcomatous change seemed to be against this view.

2. It was a primary liposarcoma of the spermatic cord which had extended down the scrotum and caused pressure atrophy and absorption of the testis. Such tumors are rare but have been recorded by Tédénat and Martin (46) and others. These tumors are characterized by varying mixture of fatty and fibrosarcomatous tissue, by very slow growth, by their large size, and by a tendency to local recurrence. The history of a swelling suggestive of a hernia in the early stages, the presence of so much heterologous fatty tissue, the slow growth, the low grade malignancy, and the local recurrence seemed to favor this view. The absence, however, of an accurate early history, the complete absence of the testis, the peculiar difference between the upper and the lower portions of the tumor made such a diagnosis unlikely, so that it was thought, in spite

Fig. 10. Bilateral lymphosarcoma of testis with a cutaneous nodule. One-half size.

of the comparative rarity of lipomatous tissue in such growths, to be an example of teratogenous lipofibrosarcoma, in which all other elements had been suppressed.

3. With this possibility in view many more sections were cut and examined and the others were carefully reviewed to attempt to discover teratogenous elements. In section No. 84, areas of calcified cartilage (Fig. 8) were discovered, while in some of the sections from the peripheral part of the fibrosarcomatous areas, involuntary muscle bundles and lymphoid areas were found. In addition examination of other sections showed scattered giant cells rather similar to those seen in Case 1. There seems to be no doubt that the diagnosis of teratogenous fibroliposarcoma for this interesting tumor is justified. It is suggested that in this case as in the preceding, the sarcoma was probably derived from the myogenous elements of a teratoma.

PRIMARY SARCOMA DERIVED FROM THE CONNECTIVE TISSUE OF THE TESTIS

Two apparently distinct types of primary sarcoma of the testis have been recorded, although on account of their rarity we are not yet in a position to be certain of their histogenesis. These tumors are composed of small round cells and have been usually described as lymphosarcomata: (a) unilateral lymphosarcoma—differing in no way from ordinary sarcoma as regards histology, course, or metastases; (b) lymphosarcoma—characterized by its appearance in both testes, by its rapid growth, and by the presence of multiple cutaneous sarcomatous nodules.

Fig. 11. Section of tumor of right testis, from same case as in Figure 10, from main tumor mass showing type of cell present. × 130.

Lymphosarcomata of the first group are very rare but apparently authentic cases have been recorded by Nicholson (36), Debarnardi

Fig. 12. Section of the same tumor as in Figure 10, showing infiltration of the epididymis. × 75.

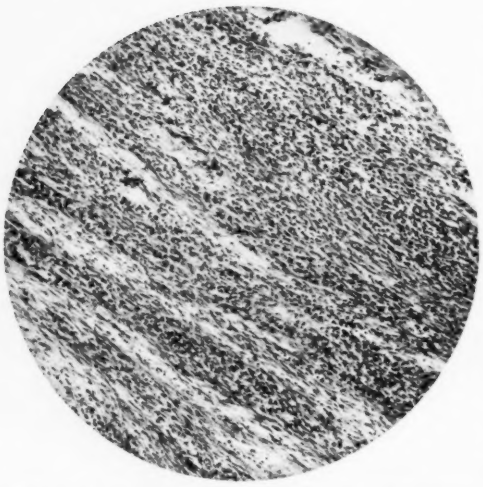

Fig. 14. Spindle cell sarcoma (fibroblastic) of the retrotesticular tissues, probably derived from the gubernaculum testis. Section from main tumor, Case 4. × 95.

(12), Ehrendorfer (17), Chevassu (7) and the writer (14). The last case has been described elsewhere and the conclusion arrived at, that, as regards histological appearance and pathological course, this tumor fulfilled the sarcomatous criteria. Figure 9 is a photomicrograph of a section of this tumor.

This tumor is held to arise from the fine intertubular connective tissue of the testis although this tissue is singularly deficient in lymphocytes. Ewing (18), in view of its extreme rarity and the frequency with which lymphoid tissue is found in teratogenous growths suggests that it may represent the one-sided development of a teratoma. Though he is inclined to regard all testicular growths as of this nature, this view must be considered before a decision is made that any small round cell growth is derived primarily from the connective tissue of the testis itself.

Bell (2) has recently drawn attention to the fact that although most of the seminoma group of carcinomata are composed of large round cells with a clear cytoplasm like the spermatocytes, others are composed of smaller cells with darkly staining nuclei and much less cytoplasm. He suggests that the mesothelial origin of the germinal cells supplies sound reasons for individual variation and believes that reversionary tendencies of these epithelial cells play a large part in the production of the so-called lymphosarcomata. The suggestion that some of these small cell tumors are really epithelial in origin is also held by Chevassu who has maintained that many cases recorded by French observers as lymphosarcomata are in reality varieties of seminoma. He suggests that these small cell types may be derived from the spermatoblasts or other precursors of the spermatocytes.

However much uncertainty exists concerning the histogenesis of the already mentioned tumors, there is no doubt that the tumors of the second group are distinct, although these too have some peculiarities which are hard to explain. Tumors of this group were first described by Curling (11) and later by the French observers: Malassez (31), Talavera (45), Monod and Terillon (34), and Réclus and Duplay (40). Cases have also been recorded by Ehrendorfer (17), Ewing (18), and Debarnardi (12). Chevassu has drawn attention to the confusion which has existed in the recent French literature where the two types of "lymphosarcomata" and seminomata are often confused under the name of lymphadenoma testis. The tumors of the second group are characterized in the majority of cases by their bilateral nature, by their rapid course, by the frequency of multiple cutaneous growths and by a histological structure resembling lymphosarcoma. The following case history illustrates some of the features of the group:

CASE 3. A. A., aged 84 years, was first seen with a painless enlargement of the right side of the scrotum, which had been noticed for some weeks. On examination a translucent hydrocele was present and no enlargement of the testicle was detected. There was slight enlargement of the other testicle at that time. About 3 weeks later examination revealed enlargement of the left testicle which had become almost as large as the right. On examination it appeared solid and was opaque to transmitted light. A week later he was seen with multiple nodules beneath the skin of both forearms and both legs not involving the thighs or arms. It seems probable, judging by their size, that these nodules were in reality present at the time of the first examination, although missed by the patient and the clinician. Two weeks later several of the subcutaneous growths began to ulcerate through the skin of the leg and he was compelled to take to

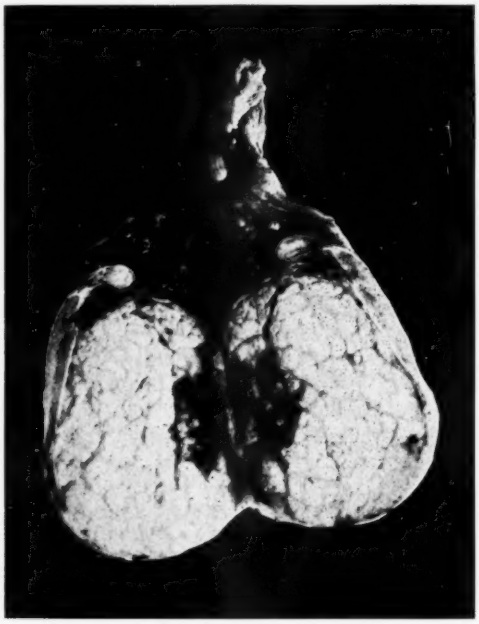

Fig. 15. Secondary embryonal sarcoma (Wilms tumor) of the left testicle. Child aged 27 months. Natural size.

his bed. These nodules, which were extremely numerous, varied in size from 0.5 to 3 centimeters in diameter, were very vascular, and caused thinning and finally ulceration of the skin. They were not painful, until they became secondarily infected from ulceration. The two testicular swellings increased, but the effusion into the tunical sac seemed to diminish, the swelling on each side becoming opaque. The epididymis on the right side appeared to be enlarged. Puncture revealed slightly blood stained fluid from the right tunica. Examination of the chest in the later stage showed some basal congestion but no signs of metastases or of pleural effusion. There was no demonstrable increase in the size of the liver or spleen, nor could any tumor be felt in the abdomen. The patient gradually became cachectic and died in a state of coma 4 months after first being seen. A full autopsy was not allowed, so that the pathological information available is unfortunately limited.

Pathology, the testicles. Both testicles were found to be the seat of a soft cellular type of growth (Fig. 10) and were about twice the normal size. The growths were homogeneous and vascular and had infiltrated the atrophic testicular substance and the epididymis. The outline was irregular and careful examination revealed several outlying foci of varying sizes, apparently separated completely from the main mass. There were several small areas of hæmorrhage, but no cystic change or central degeneration. The appearance and consistency of the tumors suggested a rapidly growing sarcoma. The cord was free, contained no neoplastic extension and no nodules. The tunica albuginea was thickened and the tunica vaginalis on both sides had obviously contained fluid. On the right side there were numerous adhesions between the two layers of the tunica, and some of the loculi thus formed contained blood clot, probably the result of the exploratory puncture.

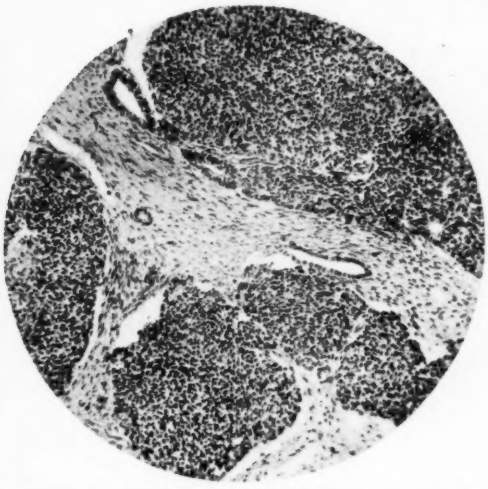

Fig. 16. Section of secondary Wilms tumor of the testis, showing mixed structure. × 106.

Microscopically the tumors were identical and were composed of small cells of lymphocytic type set in an irregular refringent reticulum (see Fig. 11). These cells had little cytoplasm, but active hyperchromatic nuclei with occasional mitotic figures. They were seen infiltrating between atrophic tubules and at the edge were mixed with cells derived from disintegration of such tubules. Around the main tumor mass were multiple foci of similar cells and in some cases these appeared to be arranged around small blood vessels. Careful search for heterotypical tissues was made throughout the greater part of one of the tumors with negative results.

The cutaneous nodules were soft and extremely vascular and had infiltrated the subcutaneous fat widely and caused pressure necrosis of the epithelium. The latter, however, did not seem to be infiltrated, a fact which is in keeping with the general sarcomatous appearances of the nodules. On microscopical examination, they revealed an irregular infiltration of the subcutaneous tissues with a small lymphocytic type of cell, similar to those of the testicular tumors.

Nature of the tumor. Two explanations of the nature of this neoplasm are possible: (a) that it is a bilateral primary sarcoma derived

from the connective-tissue elements of the testicle with secondary cutaneous metastases; and (b) that both the testicular and cutaneous tumors are metastatic and secondary to some other primary source.

In view of the small amount of lymphatic tissue in the testis, the peculiar origin of the tumors from several centers, the rarity of any other forms of bilateral neoplasm and the peculiar distribution of the cutaneous deposits, it is difficult to accept the first explanation and it has been discarded by the majority of writers.

In the cases recorded by Chevassu (8) and Monod and Terillon (34), generalized enlargement of the abdominal lymphatic glands was present and as pointed out by Chevassu, it is possible that a retrograde lymphatic spread of the neoplastic process from the retroperitoneal lymph glands may be the explanation of the bilateral testicular involvement. It may be that the abdominal lymphatic glands are the seat of a lymphosarcoma which metastasizes in this peculiar manner. Some of the French observers and more recently Cumston (10) consider that the condition is allied to an aleucæmic lymphatic enlargement, there being as a rule no coincident alteration in the nature or number of the leucocytes in the blood. Another suggestion is that the condition is a form of Hodgkin's sarcoma with a somewhat peculiar distribution of metastases. All observers are agreed upon the frequency of lymphatic glandular enlargement and of the fatal nature of these cases. Only by careful exhaustive postmortem examination will the true nature of the lesion be elucidated. From the somewhat meager knowledge at our disposal, it seems to me that both the testicular and cutaneous nodules must be regarded as part of a general lymphocytic deposition, i.e., they are metastatic.

TUMORS ARISING FROM THE INTERSTITIAL CELLS

The function of the interstitial cells is apparently to supply an internal secretion which determines the development of secondary sexual characteristics. Various observers have described tumor formation from these cells, but the exact nature of these cases has not yet been determined. Waldeyer (48) named one specimen plexiform angiosarcoma, while Hansemann (21) suggested that certain of the alveolar sarcomata and carcinomata had a similar origin. In atrophic testes in which the seminal tubules have undergone degeneration or disintegration, there is often an apparent hypertrophy of these cells and at times an appearance of overgrowth.

This led Durck (15) to report five cases in atrophic testicles, both descended and undescended, in which multiple hyperplasia of these cells had occurred. He was, however, uncertain whether the condition should be regarded as neoplastic or as a simple hyperplasia.

A comparatively large tumor, measuring 9 centimeters by 12 centimeters and composed of polyhedral cells with active nuclei and irregular mitotic figures was described by Kaufmann (24). The type of cells present and their staining reactions led him to regard it as a sarcoma, although he was somewhat guarded as to its malignancy.

Chevassu (7) also described a similar tumor about the size of a hen's egg, which was reddish yellow in color on section. The cells composing it were large with abundant cytoplasm, contained pigment and vacuoles, had small active nuclei, and were apparently identical with the interstitial cells. He thought the tumor was benign. No one has as yet observed any metastases in tumors of this type and none of the recorded cases can definitely be proved to be sarcomatous. It is important, however, to bear in mind the possible origin of malignant tumors from this source, especially in atrophic testes, and it may be that some of the typical homogeneous tumors will be proved to be derived from these cells.

SARCOMATA DERIVED FROM THE EXTRATESTICULAR STRUCTURES, THE TUNICA VAGINALIS, THE EPIDIDYMIS, AND THE SPERMATIC CORD

These tumors are comparatively rare and therefore most of them are reported, so that Hinman and Gibson (22) were able to collect a great variety of cases from the literature. These writers deal with the subject very fully and give an exhaustive bibliography.

Sarcomata of the tunica vaginalis. Hinman and Gibson were able to collect 12 cases which could be regarded as authentic sarcomata of the tunica. The cases of Home (23) and Craven (9) described by Curling (11) are the earliest recorded. The greatest difficulty is in differentiating these from tumors of the underlying organ. Apart from their rarity, they are of no special interest as they behave in a typical manner as regards course and metastases.

Sarcomata of the epididymis. As confusion has existed in the description of tumors of this region, it is not surprising that sarcoma is the most commonly recorded. However, the diagnosis of sarcoma must be accepted with reserve and an attempt made to correlate the descriptions given with modern pathological conceptions. The majority of purely epididymal tumors are probably carcinomata. Interesting cases, which appear to fulfil the sarcomatous criteria have, however, been recorded, among others, by Curling (11), Edwards (16), Russell and Wood (42), Kolster (28), Grossman (20), and Miyata (33).

Sarcomata of the spermatic cord. A great number of sarcomata of various cellular types have been recorded in this region and seem to be second in frequency to the lipomata. There seems no doubt that some of the recurrent lipomata of this region are very closely allied to liposarcomata. Series of cases have been recorded by Fasano (19), Celso (6), Tód nat and Martin (46), Patel and Chalier (38), while Hinman and Gibson (22) have fully reviewed the reported cases. Fibrosarcomata and liposarcomata are the most common types, and it seems that many of these have origin in a benign tumor, which has been growing slowly over a long period. The possibility that some of these tumors are of a teratogenous nature has been emphasized by Kolisko (27) and Ewing (18).

Sarcomata arising from the peritesticular connective tissues are rarer, although cases have been recorded by Miyata (33), Rokitansky (41), and Neumann (35). The latter have noted the presence of giant cells in these tumors and suggest the possibility of a myogenous origin from the upper part of the gubernaculum testis.

The following case history is that of a sarcoma of the retrotesticular tissues, and I believe it to be of a myogenous nature.

CASE 4. M. N., aged 17 years, stated that about 3 years before admission to the hospital, he had been struck on the left testicle by a cricket ball, but that apart from the severe pain at the time he had had no ill effects. Two and a half years later he noticed a small lump behind and below the left testicle. This was quite painless, but enlarged steadily. He had no other symptoms and appeared to be in perfect health. On examination a hard non-tender egg-shaped tumor was present below and behind what appeared to be a normal testicle. The epididymis could not be differentiated by palpation, and it was thought that the tumor was a primary growth of that organ. The cord was normal, rectal examination was negative, and the contents of the other side of the scrotum appeared normal. The Wassermann reaction was negative.

Simple orchidectomy with high division of the cord was performed, and the patient was still alive and well 3 years after the operation.

Pathology. When the tissue removed was examined, it was found that the tumor was independent of the testis, epididymis, and cord. It was fairly well encapsulated, homogeneous, of a firm consistency, and measured 7.5 centimeters by 4.5 centimeters in its longest diameters. It was pale pink in color and the cut surface resembled that of a fibrosarcoma. There were no areas of hæmorrhage, cystic degeneration, or softening. The colored plate (Fig. 13, frontispiece), gives its relations and approximate size. Below, it tended to merge into the gubernaculum testis.

Microscopical examination of the whole of one-half of the tumor was carried out by cutting serial sections. It was found to be composed in the main of fibroblastic spindle cells and conformed in all respects to the classical appearance of a spindle cell sarcoma of low malignancy (Fig. 14). The tumor was not very vascular but there was a tendency for the vascular channels to be represented by chinks with poorly developed walls rather than by definite vessels. In spite of careful search, no trace of any teratogenous elements could be discovered. In one portion of the growth a few giant cells were discovered. These cells measured up to 25μ in diameter, and had four to six centrally arranged nuclei. They resembled those seen in myosarcomatous growths of the uterus, and this suggests that this tumor is similar to that described by Neumann, being in all probability derived from the gubernaculum testis.

SECONDARY SARCOMATA OF THE TESTICLE

Secondary sarcomata of the testicle are very rare and usually develop as the result of the carriage of metastatic emboli by the blood stream from a primary sarcoma elsewhere.

Careful autopsy records in cases of general dissemination of sarcomata would doubtless reveal more of these cases than the number recorded in the literature would suggest. The probability that Case 3 is in reality metastatic has been emphasized. Secondary deposits of melanoma (melanotic sarcoma) have been recorded by Curling (11), but the literature contains very few references to other metastatic growths. I recently (13) recorded an example of a secondary Grawitz carcinoma of the left testicle in which the neoplastic tissues grew down to the left spermatic vein. The following case is of a somewhat similar nature. For a record of the case I am indebted to Dr. R. Southby, of the Children's hospital, Melbourne.

CASE 5. L. M., aged 27 months, was admitted to the hospital with a swelling of the left side of the scrotum which had been noticed enlarging for about 18 days. Six months previously he had been operated upon for an embryonal sarcoma (Wilms tumor) of the left kidney and a nephrectomy had been performed. Examination revealed a scrotal tumor, pear shaped, hard, painless, and so large that it filled the greater part of the scrotum, although the skin was freely movable over it. The epididymis could not be differentiated and the swelling was non-translucent. The cord was thickened, but the vas appeared normal. No enlargement of the inguinal or iliac glands could be detected. Orchidectomy with high division of the cord was performed and the patient recovered. The patient died with multiple metastases some 4 months later.

Pathology. Figure 15 shows the appearance of the tumor on section. The testis and epididymis and the lower part of the spermatic cord were almost completely replaced by neoplastic tissue which had a white lobular appearance. There was a slight effusion into the tunica vaginalis, and the veins of the pampiniform plexus were very large and dilated.

Microscopical examination revealed the typical appearance of embryonal tumor of the Wilms type (Fig. 16). Examination of the spermatic cord showed that some of the spermatic veins were completely filled with thrombi and neoplastic cells, and there seems to be no doubt that in this case there had been a direct intravascular spread from the renal region to the left testis along the left spermatic vein.

It is a pleasure to acknowledge my indebtedness to Miss Cecil Maudsley, who prepared the photomicrographs for me at the Walter and Eliza Hall Institute of Research, Melbourne.

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MECHANISM OF EMPTYING OF THE GALL BLADDER AND COMMON DUCT[1]

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In previous publications, although admitting the possibility of intrinsic muscular contractions of the gall bladder, we have questioned the position taken by many that these contractions constitute the only mechanism of emptying. Thus, we have stated (4): "Though the gall bladder has an elastic or contractile mechanism which exerts pressure on its contents, until it has reached a minimum pressure, we have not been able to demonstrate an actively contracting movement due to its intrinsic musculature," and again in a later article (6): "In the light of the new evidence, we feel that perhaps we have not assigned sufficient importance to the factor of intrinsic contraction of the muscle and that this factor should be added to the physical forces mentioned responsible for the emptying of the gall bladder; but we are unwilling to ascribe to muscular contractions the exclusive rôle in this drama." The observations of Boyden (2) and of Whitaker (7) that the gall bladder is frequently found collapsed after a meal of egg-yolk or fat have shed further light on the emptying mechanism.

In a re-investigation of this problem we have made use of the roentgenological method adopted by Whitaker (8) for experimental animals. The gall bladder is filled with iodized oil (iodopin) by open laparotomy, and, on the following day, after recovery of the animal, X-ray films are made. Under these conditions it is found that if the animal is starved following the operation, no emptying of the gall bladder occurs for 2, 3, or more days, but the administration of a meal of fat or preferably of egg-yolk and cream, causes a flow of oil from the gall bladder into the duodenum. This emptying of the gall bladder commences within a short time after the administration of the meal and continues over a period of 3 or 4 hours. In some cases, in the cat, the gall bladder is completely empty by this time; more frequently traces of iodopin remain and these traces may then persist until another meal is ingested (Fig. 1).

As a result of such observations, Whitaker has concluded: "The emptying of the gall bladder is produced primarily by the action of its muscular tunic, extrinsic mechanical factors having no appreciable effect" (9). Burget (3), however, does not concur with this conclusion. He states: "Although, following such procedure there is a noticeable reduction in size, to deduce from this evidence that the gall bladder expels bile by forcibly contracting would seem unwarranted in view of its great elasticity."

To exclude the effect of elasticity of the gall bladder and the other mechanical factors which have been suggested to account for its emptying, the following experiment was performed. The gall bladder of a cat was filled with iodopin and a cannula was inserted in the cystic duct, pointing upward toward the gall bladder. The cannula was attached to a thin rubber bag, made from a finger cot, which was placed in the abdomen. The following day a meal of egg and cream was administered by stomach tube and roentgenograms were made, immediately after the meal and 5 hours later (Fig. 2). At the time of the first roentgenogram, 24 hours after operation, all the iodopin was still in the gall bladder, although the elasticity of the wall and the changes in the intra-abdominal pressure had had every opportunity to function. Five hours after the egg meal a considerable degree of emptying of oil from the gall bladder into the rubber bag had taken place. It would seem from this experiment that the discharge of bile from the gall bladder is not necessarily dependent upon elasticity or extrinsic factors and may be the result of muscular activity.

Doubtless, however, muscular activity is not the sole agent normally engaged in the

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Fig. 1. Iodized oil in gall bladder of cat. Upper picture, 24 hours after operation, before egg meal. Lower picture, 5 hours after egg meal. Gall bladder now almost empty. Traces of oil in the colon.

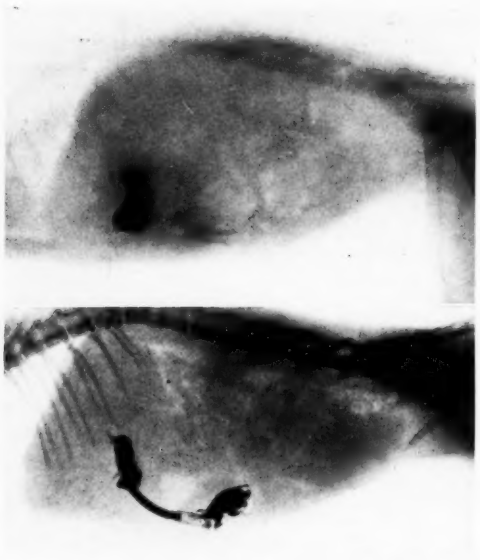

Fig. 2. Upper picture, iodized oil in cat's gall bladder 24 hours after operation. Glass cannula in cystic duct leading to intraperitoneal bag. Lower picture, 5 hours after giving egg meal by stomach tube. Partial emptying of the gall bladder into the rubber bag.

emptying; we believe that two other factors particularly take place in this process, namely: (1) a flushing out by the flow and ebb of fresh bile from the liver and (2) elastic recoil of the distended viscus. The question of flushing out of the gall bladder by bile from the liver has been considered in a previous paper (4). It was shown by cholecystography that a rubber bag substituted for the gall bladder of a dog will fill and empty somewhat after the manner of the normal viscus. Further evidence of the importance of this factor is offered by the following experiment: In a dog, the hepatic ducts were ligated, above the entrance of the cystic duct, and the gall bladder was filled with lipiodol. Complete emptying had not occurred at the end of 30 days, although during this time the dog was fed egg-yolk and cream in addition to regular diet. This result indicates that the ebb and flow of bile from the liver is a factor of some importance in the emptying of the gall bladder.

In many animals, the anatomical arrangement of the gall bladder which may be closely attached to a large area of liver or even completely embedded in it, renders the flushing out by bile of especial importance, for in these cases, it is difficult to see how even vigorous contraction of the wall could completely empty the gall bladder. In the monkey (macacus rhesus), in which this anatomical arrangement is the rule, complete emptying of the gall bladder may be delayed for as long as 11 days, even if meals of egg-yolk and cream are administered (Fig. 3).

It is difficult to determine whether the muscular activity of the gall bladder is of the nature of a true peristaltic action or of a change in tonus. Changes in size and shape of the gall bladder as seen on X-ray films have been taken to indicate the presence of peristaltic action, but such evidence is not conclusive since similar changes in shape may result from other causes, such as the pressure of other viscera. This point is demonstrated by Figure 4 which shows a cat, in the abdomen of which

Fig. 3. Upper picture, gall bladder of monkey filled with iodized oil, 24 hours after operation, before egg meal. Lower picture, 7 days later, after several egg meals, very little emptying has taken place.

Fig. 4. Abdomen of cat with rubber bag filled with iodized oil. Note the changes of configuration suggestive of peristaltic waves.

was placed a rubber bag partly filled with iodopin. Changes in shape are seen which are, of course, entirely due to variations of pressure from adjacent viscera. These changes might easily be misinterpreted as being due to peristalsis.

This pressure of adjacent organs (that is, the intra-abdominal pressure) has been adduced by many investigators to explain the emptying of the gall bladder as well as its change of shape. Apparently, however, it plays a very minor rôle. In the experiment previously described, in which the cystic duct of a cat was catheterized by a glass cannula leading to an intraperitoneal rubber bag, vigorous struggling, due to the passage of a stomach tube, failed to express a single drop of iodopin from the gall bladder (Fig. 2). Further investigations of the importance of this factor point to the same conclusion. In a dog, a cannula leading to a rubber bag was inserted into the common duct, and the wound tightly closed around a rubber tube. The intra-abdominal pressure was then alternately raised and lowered by passing air through the tube into the abdominal cavity, the pressure varying from 0 to 60 centimeters of water. After half an hour of such variations in the pressure, the bag was examined and found to contain merely a few drops of bile, expressed from the ducts; the gall bladder remained full.

As it was felt that objection might be raised to this experiment, because of the presence of air in the peritoneal cavity, a further experiment was performed in which variations of pressure were induced comparable to those occurring normally. In this case, in a dog, the common duct was intubated with a cannula and the abdominal pressure was then raised periodically, to simulate respiration, by the forced insufflation of air into the trachea, counter pressure being applied to the abdominal wall by means of a tight binder. Consider-

Fig. 5. Upper picture, concentrated solution of sodium iodide in gall bladder of cat, cystic duct ligated. Lower picture, eighteen hours later, gall bladder empty, urinary bladder filled with sodium iodide.

able changes in intra-abdominal pressure, such as coughing, caused no change in the size of the shadow of the gall bladder, and even when the cannula was led outside of the abdomen, only a few drops of bile, the actual duct content, were expelled. It would seem, therefore, that the intra-abdominal pressure plays a very small part in the emptying mechanism of the gall bladder.

NATURE OF THE RESPONSE OF THE GALL BLADDER TO THE EGG MEAL

The observation of Sosman (2) that the gall bladder emptied normally in a patient who had had a resection of the pylorus and gastrojejunostomy, suggests that the response does not depend upon local stimulation of the mucous membrane of the duodenum. Whitaker claims that the emptying of the gall bladder is independent of the flow of pancreatic juice, but we have not confirmed this latter finding. We excluded pancreatic juice from the duodenum by separating the pancreas from the duodenum and by ligating the pancreatic ducts in 3 cats and 1 dog, and in these animals no emptying of the gall bladder occurred after successive meals of egg and cream.

There is some evidence that the gall bladder is influenced by certain internal secretions, such, for instance, as adrenalin, but the interpretation of this action is not quite clear, for after complete removal of both suprarenals, the gall bladder empties normally in response to a fat meal, an observation made by Boyden and confirmed by us. In a further investigation of a possible hormonal action, we have injected intravenously secretin, insulin, pancreatic juice, and alcoholic and acid extracts of cow and dog gall bladder, all of which injections had no effect on the size of the gall bladder. Nor did the direct injection of egg-yolk[1] into the gall bladder accelerate its emptying.

COMMON DUCT

The common duct is generally looked upon as merely a passive channel and indeed its thin walls and the paucity of muscular fibers lend support to this belief. Nor has any spontaneous movement of the common duct been observed in man or other mammalia. Comparative and experimental studies suggest that it may have a more important rôle, for in many fowls the common duct exhibits well-marked muscular contractions. The contractions are easily seen in the pigeon and other birds, as has been observed by Doyen (5) and others. To observe these contractions in the pigeon the abdomen is opened, under ether anæsthesia, and access obtained by removing the lower part of the sternum. Active movements of the common duct are then readily visible. They occur quite frequently, sometimes every 5 or 10 seconds, and are of true peristaltic nature, a wide relaxation phase preceding the contraction and extending rapidly from the portal fissure down to the papilla of Vater. As the duct is thin-walled, it is easy to see dark bile accumulating at the upper end of the duct and then rapidly being propelled down into the intestine. If the lat-

[1] Since submitting this paper for publication, Ivy and Oldberg (J. Am. M. Ass., 1928, Feb. 11, xc, 445) have reported the demonstration of the contraction and evacuation of the gall bladder of the cat and dog after the injections of a highly purified "secretin" preparation.

ter is opened, a spurt of bile is seen to follow each contraction.

We have attempted to show, in the cat, movements of the common duct by an indirect method. The common duct was filled with iodopin and all the hepatic ducts and the cystic duct were ligated to prevent its being washed out by fresh bile. Roentgenograms taken at intervals showed that the common duct emptied during a period of 12 hours. This seems to indicate active movements of the common duct but other factors, such as the action of the duodenum, may be present.

ABSORPTION FROM THE GALL BLADDER

In searching for an alternative opaque material to iodized oil for experimental use, we found that sodium iodide rapidly disappears after injection into the gall bladder. This rapid disappearance, at first believed to result from emptying from the gall bladder, proved to be due to its absorption through the gall-bladder wall and occurred just as rapidly after ligation of the cystic duct. Chemical tests showed the complete disappearance of the sodium iodide from the gall bladder within a few hours. Subsequent roentgenograms showed its presence in the urinary bladder (Fig. 5). The process is probably a physical one, not dependent upon a specific property of absorption by the gall-bladder wall. The disappearance of the sodium iodide from the gall bladder after ligation of the cystic duct was not hastened by the administration of a fat meal.

CONCLUSIONS

The emptying mechanism of the gall bladder is dependent partly upon an intrinsic muscular action, partly upon its elasticity, and partly upon the ebb and flow of fresh bile from the liver. The last factor is of especial importance in animals in which the anatomical arrangement of the gall bladder precludes its complete contraction, as in the monkey. Variations of intra-abdominal pressure play a minor rôle in the emptying of the gall bladder. Peristaltic contractions of the common duct have been observed in pigeons and it is suggested that they may take part in the flow of bile in some mammalia. The response of the gall bladder to a fat meal depends upon its absorption through the intestinal wall. It is not proved whether the response of the gall bladder is due to hormone action or nervous excitation. Sodium iodide is absorbed by the gall-bladder wall.

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GALL-BLADDER FUNCTION AFTER DIVISION OF THE COMMON DUCT AND TRANSPLANTATION OF THE PROXIMAL SEGMENT

With a Histological Study of the Repair at the Site of Transplantation[1]

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ACCORDING to the law of contrary innervation promulgated by Meltzer (7), bile storage and bile discharge are controlled by a mechanism of reciprocal reflexes between the gall bladder and the sphincter of Oddi. The observations of Potter and Mann (8), and McMaster and Elman (6), supported this view. On the other hand, Burget (2) and Copher and Kodama (3), minimized the importance of the action of the intramural segment of the common duct, and emphasized the rôle of the duodenal musculature in the control of the flow of bile into the intestine.

In order to determine experimentally whether the sphincter is essential for normal gall-bladder function, complete exclusion of the sphincter and complete severence of its neuromuscular continuity with the gall bladder must be insured. In addition, a reliable method of observing the action of the gall bladder under relatively normal conditions is necessary. A consideration of these factors suggested the procedure which was employed in the following experiment.

The common duct was divided extramurally, and the proximal segment was transplanted to another part of the duodenum. This allowed the duodenal musculature to act directly upon the wall of the duct (which was practically free of intrinsic smooth muscle fibers); the sphincter was eliminated, and the neuromuscular connection with the gall bladder was severed. In order to insure firm union at the site of the transplantation, a number of weeks were allowed to elapse. Then the function of the gall bladder was determined by means of serial cholecystograms made according to the method described by Graham, Cole, and Copher (5). This method was chosen because it permitted frequent observations of the filling and emptying of the gall bladder under normal conditions.

TECHNIQUE

Under ether anæsthesia, and with aseptic precautions, the common duct in 2 dogs was isolated and doubly ligated just above its entrance into the duodenum. A linear incision 2 centimeters long was made in the anterior surface of the duodenum, 6 centimeters and 8 centimeters, respectively, from the pyloric sphincter. The duct was divided ½ centimeter proximal to the ligature and the free end was fixed at the lower angle of the opening in the duodenum which was then closed by 2 inversion sutures. Silk was used throughout.

Cholecystograms were obtained in the following manner: 0.12 grams of sodium tetraiodophthalein per kilo bodyweight was injected intravenously. Eighteen hours after the injection of the dye, the first X-ray film was taken. Then the dogs were fed with the yolks of 3 eggs in 200 cubic centimeters of cream (1), and films were taken at intervals of 1, 3, 6, and 24 hours after the meal.

EXPERIMENTAL RESULTS

Dog 8715. Male. Weight 15.4 kilos. Operation, October 21, 1926. The proximal stump of the divided common duct was implanted into the duodenum 6 centimeters from the pyloric sphincter. The pictures of the first series of cholecystograms were taken December 14, 1926, 54 days after operation. The gall-bladder shadow was normal in size and density at the 18-hour observation. Following the feeding of the egg-yolk-and-cream mixture, there was a progressive diminution in the density of the shadow but only a slight decrease in size, at the 1-, 3-, and 6-hour periods. After 24 hours the shadow was still present.

A second series of X-rays was taken April 12, 1927, 119 days after the first series. The gall-bladder shadow was of normal size and density at the 18-hour period. After the meal, however, the results differed from those obtained at the previous examination. At this observation, there was a progressive decrease in the size of the shadow with an increase in the density, at the 1- and 3-hour periods. At 6 hours the shadow was about the same as at 3 hours.

[1] A preliminary report of this work appeared in the Proc. Soc. Exp. Biol. and Med., 1927, xxiv, 434. The work was aided by a grant from the Eli Lilly Company.

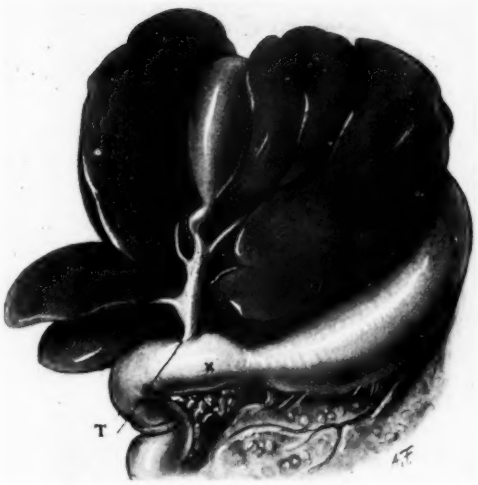


Fig. 1. Gross appearance of the gall bladder and bile ducts of Dog 8715, 175 days after the transplantation of the proximal segment of the divided common duct. *X* indicates the site of the ligated sphincter of Oddi, and *T*, the site of the transplantation. Half size.

After 24 hours, it had disappeared completely (Fig. 3).

The dog was in excellent condition and was killed with ether on April 14, 1927, 175 days after operation. The gross appearance of the gall bladder and bile ducts at autopsy is shown in Figure 1. The size and shape of the gall bladder corresponded closely to the cholecystograms; it was filled with dark green, viscid bile which was sterile upon culture. The cystic duct was normal. The common duct and the main hepatic ducts were dilated. The intramural segment of the transplanted duct was patent. The site of the choledochoduodenostomy was 4 centimeters from the pyloric sphincter; this was closer to the pylorus than at the original transplantation due probably to retraction of the duct during the process of healing. A few thin omental adhesions surrounded the lower end of the duct. The old distal stump of the divided common duct was recognized by a small nodule on the posterior surface of the duodenum (indicated by *X* in Fig. 1).

Dog 8716. Male. Weight, 11 kilos. Operation, October 25, 1926. The proximal end of the divided duct was implanted into the duodenum 8 centimeters from the pyloric sphincter. The first series of cholecystograms which was taken December 7, 1926, 43 days after operation, showed a gall-bladder shadow of normal outline and density at the 18-hour observation. After the feeding of egg yolk and cream, the following changes occurred: at 1 hour the shadow was smaller and more dense; at 3 hours it had returned to its original size; at 6 hours there was again a definite diminution in size with increased

Fig. 2. Dog 8715. Transplanted duct in the muscularis of the duodenum. Due to the tortuous course of the duct, the proximal, *P*, and the distal, *D*, ends appear in the same section. ×15.

density. After 24 hours, the shadow had disappeared (Fig. 6). At the time of this cholecystography, the dog was in good condition, but subsequently it lost weight.

A second series of films which were taken March 11, 1927 (94 days after the first series), did not disclose a gall-bladder shadow. Additional series were taken March 18 and March 29, with the same negative results. The dog was killed with ether on April 9, 1927, 166 days after operation. At autopsy, numerous adhesions were found at the site of the transplantation which was 6 centimeters from the pylorus. One of the adhesions extended over the cystic duct and occluded its lumen. The gall bladder contained a small amount of thick, inspissated bile; its wall was thickened. The common duct was slightly dilated. The intramural portion of the duct was patent. The site of the original occluded sphincter was identified.

In both dogs microscopic examination of the liver, gall bladder, hepatic and smaller bile ducts, and pancreas revealed no abnormalities. The epithelium of the common duct was flattened.

RESULTS

In order to interpret properly the cholecystograms which were obtained after division and transplantation of the extramural segment of the bile duct, they were compared with the gall-bladder shadows obtained from 2 normal dogs under the same conditions, the same technique being used. In the first dog, a normal cholecystogram was secured, and the feeding of egg yolk and cream caused a progressive diminution in the size of the

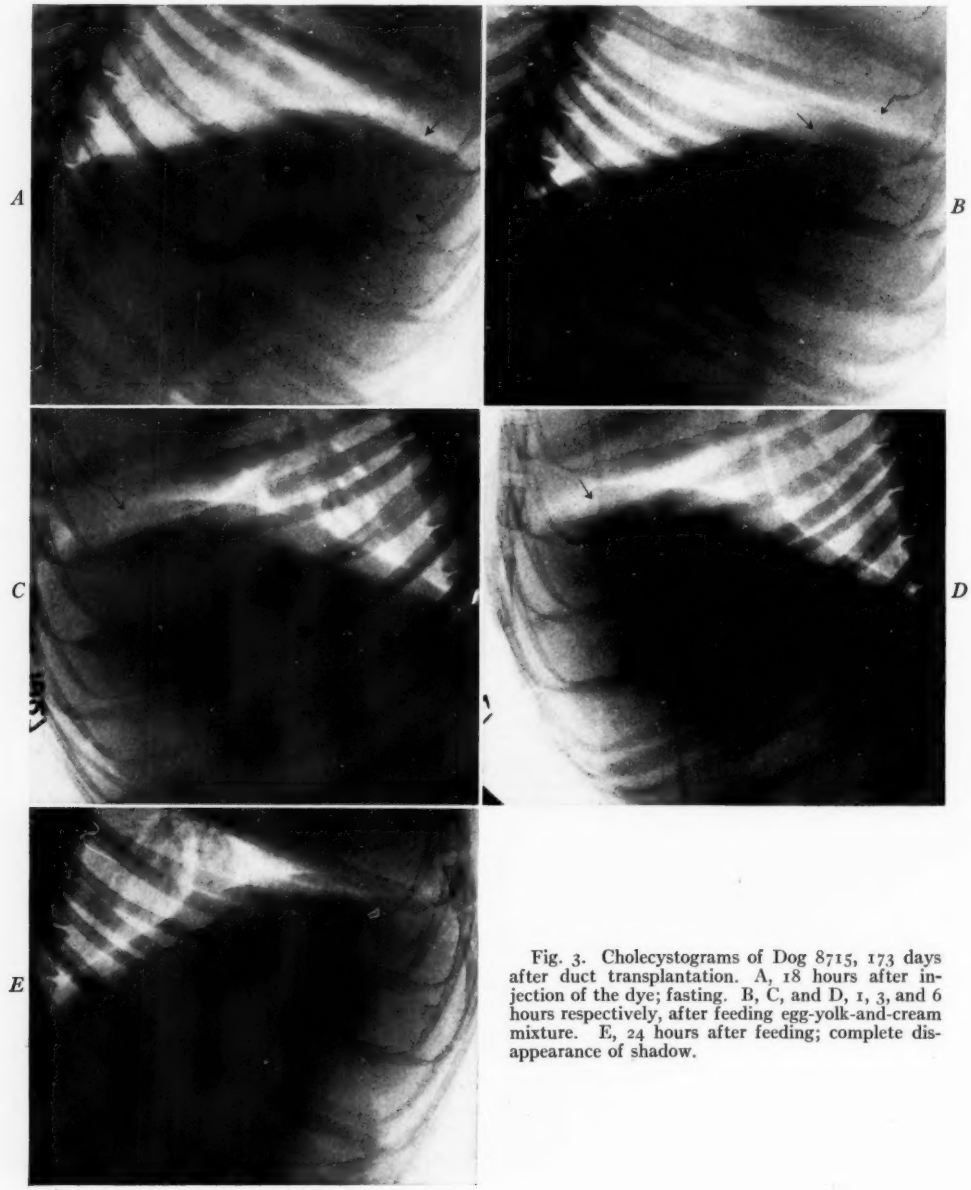
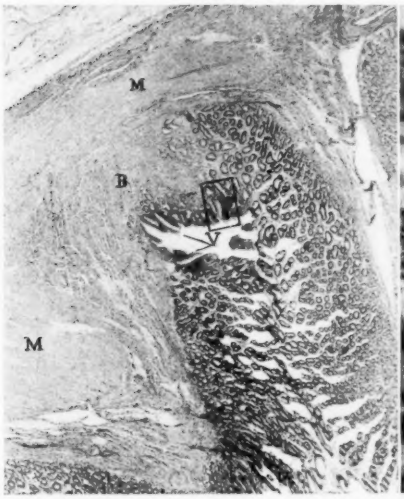


Fig. 3. Cholecystograms of Dog 8715, 173 days after duct transplantation. A, 18 hours after injection of the dye; fasting. B, C, and D, 1, 3, and 6 hours respectively, after feeding egg-yolk-and-cream mixture. E, 24 hours after feeding; complete disappearance of shadow.



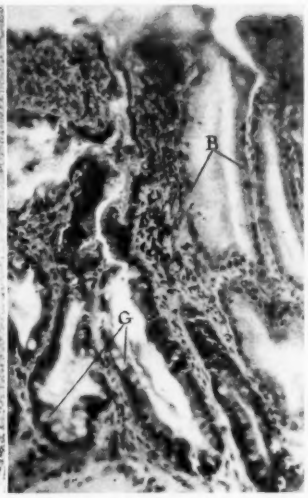


Fig. 4 (left). Dog 8715. At the opening of the transplanted duct in the duodenum. The muscularis of the duodenum, *M*, surrounds the base of the bile duct *B*, which has villi, *V*, protruding into the lumen of the intestine. ×15.

Fig. 5. Dog 8715. Transition from bile duct epithelium, *B*, to intestinal epithelium characterized by "goblet cells," *G*. Taken from the area included in the rectangle in Figure 3. ×225.

shadow with an increase in density at the 1- and 3-hour observations; at 6 hours, the shadow was the same size as at 3 hours, but less dense; after 24 hours it could be outlined faintly. In the second dog, feeding caused no perceptible change in the size of the shadow but its density was decreased in the 1- and 3-hour films; at 6 hours the cholecystogram was practically the same as the original one; at the end of 24 hours a definite shadow was still present. These observations indicated the variations that occurred in the cholecystograms of normal dogs following an egg-yolk-and-cream meal. Similar variations were observed by Graham (4) in dogs, and by Whitaker and Boyden (9) in man.

A comparison of the roentgen appearance of the gall bladder in the experimental dogs with that of the normal dogs showed that the experimental results were well within the limits of normal variations.

The persistent absence of a gall-bladder shadow in dog 8716 in the second series of roentgenograms was explained at the autopsy by the discovery of an adhesion which occluded the lumen of the cystic duct. This occurred subsequent to the earlier series in which the filling and emptying of the gall bladder were normal.

STUDY OF THE REPAIR

Athough choledochoduodenostomy has been performed successfully in man and in dogs, little is known about the nature of the repair at the site of the transplantation. The 2 dogs which were used in the preceding experiment afforded the opportunity to make a detailed histological study of the intramural portion of the transplanted duct and the process of healing.

The segment of the duodenum which contained the transplanted duct was removed immediately after death and fixed in Zenker's fluid. Then the specimen was embedded in paraffin and serial cross sections were made and stained with hæmatoxylin eosin and by Van Gieson's method.

The character of the repair was essentially the same in both dogs. Due to the fact that the duct penetrated the duodenal musculature in an irregular S-shaped manner, two lumina appeared in some of the sections: *P*

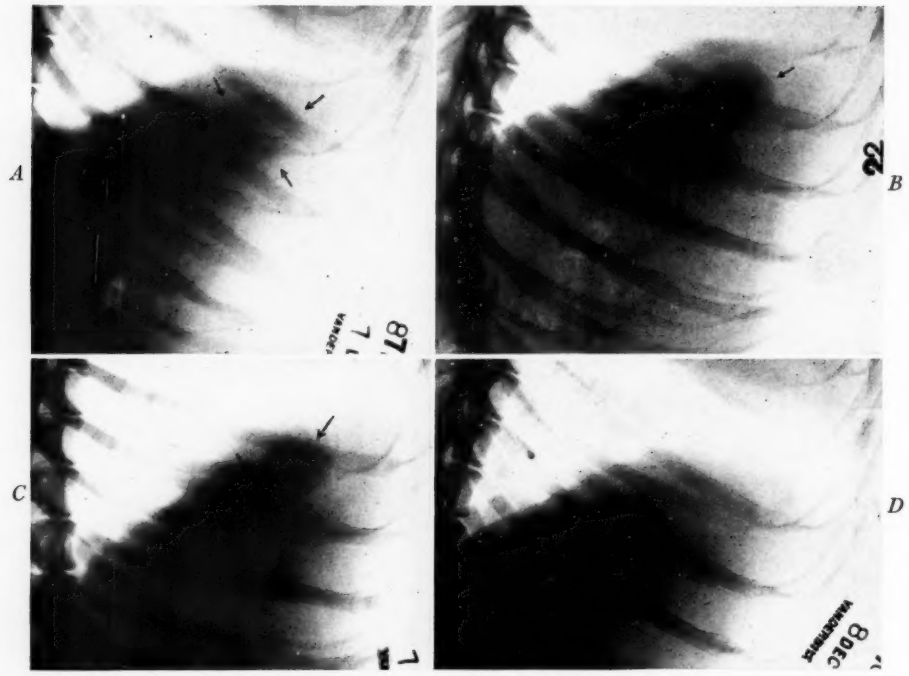


Fig. 6. Cholecystograms of Dog 8716, 43 days after duct transplantation. A, 18 hours after injection of dye; fasting. B and C, 3 and 6 hours respectively after feeding egg-yolk-and-cream mixture. D, 24 hours after feeding; complete disappearance of shadow.

representing the proximal end, and, *D*, the distal end of the same duct in Figure 2. The lumen of the intramural part of the duct was smaller than that of the somewhat dilated extramural segment.

The structure of the duct remained intact. The wall consisted of fibrous tissue interspersed with a few smooth muscle fibers and was united to the adjacent duodenal musculature by a layer of connective tissue which was practically an integral part of the wall itself. The mucosa was thrown up into folds and villi which were lined by simple columnar epithelium (Fig. 2). Toward the periphery of the cells, the cytoplasm contained fine lipoid droplets which are found normally in the epithelium of the biliary tract. A few glands lined by the same type of cell were present in the submucosa.

The transition from bile-duct epithelium to intestinal epithelium occurred at the duodenal orifice of the duct (Fig. 4) and was identified by the appearance of "goblet" cells (Fig. 5). The site of union of the apposed surfaces of the duodenum was marked by an irregularity in the arrangement of the smooth muscle fibers and a thin connective-tissue scar. Some of the sutures were still *in situ*.

No histological changes were observed in sections which were made of the original obliterated sphincter of Oddi. The epithelium stained well; the villi, which are a normal feature of the mucosa of the sphincter, were present, and the smooth muscle fibers of the wall were intact.

The fact that normal cholecystograms were obtained, indicated that the flow of bile into the duodenum was not affected appreciably by the distortion of the duct which was found at the site of the transplantation.

The regeneration of the mucosa of the transplanted duct was characterized by the for-

mation of villi. Normally, the latter are not found in the mucosa of the extramural segment of the common bile duct. The union between the duct epithelium and the intestinal epithelium occurred at the orifice of the duct without any interruption in the continuity of the mucosa.

After prolonged ligation and disuse, the structure of the original sphincter remained unaltered.

SUMMARY

1. After complete division of the common duct and transplantation of the proximal segment, relatively normal cholecystograms were obtained in dogs.

2. A specialized neuromuscular relationship between the gall bladder and the sphincter of Oddi was excluded.

3. A study of the repair at the site of the transplantation was made.

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CONGENITAL ARTERIOVENOUS COMMUNICATIONS[1]

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ABNORMAL communications between arteries and veins may be divided into two groups: congenital and acquired. The latter are the result of trauma, often in the form of stab and bullet wounds, and form the majority of such conditions. The former are rare and, therefore, all the more interesting; there is no history of trauma, but they manifest themselves at birth or a varying time afterward, and run a progressive course. Callander, in 1920, published a comprehensive review of the literature on arteriovenous fistula, collecting records in all of 447 cases, beginning with that described by William Hunter in 1757. He found that 383 of the cases were due to trauma, that in 34 the etiology was unknown, and that the remaining 3 were of congenital origin, these being reported by Bushe, Hewett, and Halsted. One realizes, of course, that cases of the congenital type are probably not so rare as the paucity of the number of recorded cases would lead one to suspect, many no doubt having escaped report in the literature. Callander's review shows well the preponderance of cases of the acquired type usually found.

Bushe's patient was a girl, aged 2 years and 7 months, presenting a purple pulsating tumor, about 2 centimeters by 1 centimeter, in the region of the right temple. The tumor had existed and gradually enlarged from birth, and for the 3 months prior to examination had been attended by hæmorrhage. While pressure was being made on the carotid vessels, Bushe removed the tumor "with a few quickly executed sweeps of a scalpel." With pressure on the carotid released, almost the whole of the raw surface spurted blood, the hæmorrhage being controlled at first by the actual cautery, though eventually ligation of the external carotid was necessary.

In the case reported by Hewett, the patient was a girl, aged 17 years, whose right thigh from birth had been larger than the left. As long as the patient could remember she had had a peculiar "beating" in the affected limb. At first the swelling was confined to the thigh, spreading later to the leg and finally involving the foot. The report says that hydrocephalus was present in infancy (evidence of a concomitant congenital anomaly). Examination showed the right lower extremity much enlarged and 5 centimeters longer than the left; the superficial veins were large and tortuous, although quite soft and easily emptied of their contents. In the enlarged femoral vein, a distinct vibratory thrill could be felt and traced upward to the juncture of the two iliac veins, where it ceased. A loud, continuous, blowing sound could be traced up the vein to the same spot. There was a loud systolic murmur at the apex of the heart, but the size of the organ was not mentioned. Hewett's treatment consisted in placing harelip pins under all the veins he could see and compressing the vessels by twisted sutures placed under the pins which were allowed to remain in place 28 days. The treatment was not successful and the patient was dismissed *in statu quo*. Hewett believed that an arteriovenous communication existed on the right side between the common iliac vessels at their point of crossing.

Halsted's case, of much more recent date, was a girl, aged 11 years, with a throbbing swelling in the right side of the neck. A throbbing and buzzing were discovered 3 days after birth, but an actual swelling was not observed until the ninth year. At operation a fistula was found between the external carotid near its origin and one of a mass of greatly dilated veins. Great dilatation of both common and external carotid arteries was noted, whereas the internal carotid was surprisingly small. The heart was normal and even in rhythm. At the time of a second

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operation 6½ years later there were no signs or symptoms of cardiac involvement.

The most recent cases of congenital arteriovenous fistula were reported by Reid (16), a former pupil of Halsted. There are 6 in all, including that of Halsted, Reid having had occasion to perform an operation on the patient 6½ years after his former teacher. The situations of the lesions in the 5 new cases were as follows: the left lower eyelid, the right subclavian and transversalis colli vessels, the left anterior tibial vessels, the right cerebral vessels, and, between the internal carotid artery and the cavernous sinus. Thus 4 were in the head and neck, and 1 in an extremity.

We are reporting here 9 additional cases of congenital abnormal communications between arteries and veins, which have been seen at the Mayo Clinic since 1916. We were able to carry out detailed clinical studies in Cases 3, 5, and 8.

REPORT OF NEW CASES

CASE 1. A girl, aged 23 years, had been troubled since birth by a bunch of bluish dilated veins over the right occipital and temporal regions. Trauma apparently aggravated the congenital condition, for after the age of 10 years, when she was struck by a stone near the dilated veins, these began to enlarge and the dilatation gradually extended downward into the neck.

A large mass evidently of pulsating veins was seen over the right lateral aspect of the head and the right side of the neck (Figs. 1 and 2). There was a loud bruit audible throughout the mass and a marked thrill just in front of the ear. The systolic blood pressure was 116 and the diastolic 90; the pulse rate was 84. A systolic murmur was heard at the apex of the heart, but there was no enlargement of the organ.

The first operation was performed August 3, 1916: Arteriovenous anastomosis was found on the right side of the neck and on the scalp extending to the median line in the parietal and occipital regions. Distinct pulsation was evident throughout the entire mass. The largest vein in the neck was apparently the external jugular, which extended down over the sternum and reached the median line. This vein was about 2.5 centimeters in diameter. Ligation of the external carotid stopped pulsation in the entire mass. The veins of the neck were excised.

At a second operation, August 11, the incision was carried from the front of the ear up to the median line and over the occiput; a flap was turned back and cirsoid vessels dissected out. Some of the vessels were ruptured during the operation and a great deal of hæmorrhage ensued. A slight amount of pulsation

Fig. 1 (left). Dilated veins of right side of head and neck (Case 1).

Fig. 2. Head shaved, showing mass of dilated veins in scalp (Case 1).

was observed in the vessels at this operation. The patient recovered from the operations, but died about 2½ months later from bilateral pulmonary emphysema and bronchopneumonia.

CASE 2. A girl, aged 10 years, complained of prominence of the eyes. Nothing abnormal had been noticed until she was about 4 years of age, when the right eye appeared more prominent than the left. This prominence had become more noticeable as time went on.

There was some degree of exophthalmos of the right eye; large subcutaneous dilated veins were visible above the inner canthus and the medial half of the eyebrow. The eye could be pushed back ½ inch into the orbit and the swelling about the medial part of the eye could be easily reduced by pressure. A typical arteriovenous thrill and murmur could be felt and heard over the veins. The systolic blood pressure was 115 and the diastolic 74; the heart was normal.

At operation, February 12, 1918, the right external carotid artery was ligated. The exophthalmos, pulse, and thrill disappeared and the patient has not had further trouble.

CASE 3. A man, aged 20 years, had been born with the right arm larger than its fellow (Fig. 3). The condition did not cause symptoms until he was 11 years of age, when he began to have spells during which the arm became swollen and painful with accompanying general malaise. After the second spell, the wrist and fingers became ankylosed and suppuration of the middle finger ensued. The patient first came to the Mayo Clinic in 1919, when the right arm was seen to be of greater girth than the left, also exceeding it in length by 1.25 centimeters. A pronounced arteriovenous bruit was heard in the palm and also in the clavicular region of the right side. Roentgenogram of the hand showed destructive arthritis of the proximal ends of the metacarpal bones

Fig. 3. Swelling of right forearm, hand, and fingers (Case 3).

and of the bones of the carpus. The ulnar and radial arteries were ligated and divided. At operation all the vessels in the neighborhood of the wrist joint were seen to be enlarged. Following the operation the size of the hand was reduced one-third, and the bruit and pulsation were considerably diminished. The patient was again seen in 1920. Six months previously he had noticed a dark scab over the first joint of the right little finger. One month previous to his visit, the scab gave place to progressive ulceration. Amputation through the middle of the forearm was performed. The pathological report was gangrene of the fingers and half of the hand, with ulceration of the dorsal surface of the little finger.

The patient returned in 1924 because of swelling in the region of the right clavicle. There was swelling in both the supraclavicular and infraclavicular spaces on the right side. The stump of the right forearm was about three times normal size but tapered off toward the shoulder. A systolic pulsation was visible in both clavicular areas, and a systolic thrill was best obtainable in the right supraclavicular space. The whole arm pulsated with each systole. A loud, continuous bruit, with systolic exacerbations, could be heard throughout the right arm and clavicular region, most marked in the supraclavicular space. The superficial veins of the right arm were dilated to three or four times their normal size. The heart was markedly enlarged, the apex beat being visible in the sixth intercostal space. The systolic blood pressure was 117 and the diastolic 56; the pulse rate was 72. The surface temperature of the right-arm was 96.4 degrees F. and of the left 91 degrees F. The blood in the veins of the right arm was examined according to the method applied in the study of arteriovenous aneurism by Brown. It was almost arterial in character as seen from the oxygen saturation (Table I). No further operative measures were carried out at the Mayo Clinic. The patient has since had the arm amputated at the shoulder. Several attempts to trace this case have not been successful.

TABLE I.—OXYGEN STUDIES OF VENOUS BLOOD IN VICINITY OF ARTERIOVENOUS FISTULÆ

	Oxygen content volumes, per cent		Oxygen capacity volumes, per cent	Oxygen saturation, per cent	
Case 3	Right arm (diseased)	Left arm		Right arm	Left arm
	20.5	7.0	22.8	90	30
Case 5	20.2	11.7	20.4	99	55
Case 8	Right leg	Left leg (diseased)		Right leg	Left leg
	4.2	17.1	17.9	23	95

Case 4. A man, aged 21 years, complained of a small hard lump which had developed "of its own accord" on top of his head 5 years before; there had been no soreness or breaking down. His physician, thinking it was due to inflammation, incised the tumor which bled so furiously that the incision had to be packed. Since then the lump had gradually increased in size, spreading downward and forward as far as the left eyebrow. The patient complained that the tumor was painful to the touch and noticed that it varied in size, increasing when he became hot or excited, diminishing in cold weather or when he was quiet.

On the left of the scalp, extending forward over the corresponding eyebrow, a pulsating mass was seen. In its upper part, the mass was circumscribed and there were a few petechiæ on its surface. Anteriorly the bulging was not so great, but several large tortuous vessels were visible. Over the entire mass, an expansile thrill could be felt and a loud murmur heard. The tumor could be reduced considerably in size by pressure. The systolic blood pressure was 140, and the diastolic 110; the pulse was 100. The heart was normal.

At operation, February 22, 1921, the area of swelling was first encircled with a catgut hæmostatic stitch and the huge dilated veins were removed. A circular suture was then placed from beneath in the tissues of the scalp encircling the entire incision. Since the operation there has been no further trouble.

The congenital origin of this aneurism is open to considerable doubt. The absence of any history of trauma is not conclusive evidence. The onset of the tumor at the age of 16 years suggests that the lesion was acquired.

Case 5. A man, aged 30 years, came to the Mayo Clinic in 1925 on account of the progression of an abnormality of the right upper extremity. This, he stated, had always been larger than the left. At about the age of 13 years, he injured the right little finger while playing baseball and it gradually became ankylosed. He then found that even a slight abrasion of this finger took 1 or 2 months to heal. In 1918 he began to notice that the veins on the back of his hand were becoming more prominent and became aware of a tendency toward numbness in the affected arm and hand. This had interfered greatly with his work. He first visited the Mayo Clinic in 1922, when a typical arteriovenous thrill was felt at the base of the thenar and hypothenar eminences. A bruit, with systolic exacerbations, could be heard over the area of thrill.

TABLE II.—SURFACE TEMPERATURES OF UPPER EXTREMITIES IN CASE 5, MAY 17, 1925; ROOM TEMPERATURE 23.8 DEGREES C.

Area	Temperatures° C. Right	Left
Tip of third finger	30.9	30.8
Tip of thumb	31.2	31.0
Knuckles	31.5	30.1
Dorsum of wrist	31.65	29.8
5 cm. above wrist	31.7	30.5
15 cm. above wrist	33.3	30.5
10 cm. below elbow	33.5	31.0
5 cm. above elbow	32.7	31.8
15 cm. above elbow	33.3	31.5
10 cm. below shoulder	33.3	32.3

There was atrophy and gangrene of the distal phalanx of the little finger. An arteriovenous aneurism of the right ulnar artery and vein just distal to the annular ligament was excised, and the artery proximal to the aneurism was seen to be enormously dilated, its diameter being about 2.5 centimeters. The radial artery was exposed and found to communicate with a large vein in the anatomic snuffbox; both artery and vein were ligated. The ankylosed little finger was also amputated at this time. In 1923, ulceration of the index finger took place although there was no history of trauma, and gangrene ensued. The patient returned and the finger was amputated. He became gradually worse and the right hand became a direct hindrance to him. In 1925, dry trophic ulceration appeared at the site of amputation of the index finger and on the middle finger.

Numerous large, dilated, tortuous, and pulsating veins were seen on the forearm and dorsum of the right hand, being more marked on the medial side (Fig. 4). A thrill was felt and bruit heard as far proximally as the middle of the arm. The right arm was 1.25 centimeters longer than the left and averaged between 4 and 5 centimeters more in circumference than the left. The systolic blood pressure was 120, and the diastolic, 80. The pulse rate was 85. The heart was markedly enlarged, the apex downward and to the left, and a marked systolic thrust was seen over the lower part of the præcordium. There was a systolic murmur over the base. No signs or symptoms of cardiac decompensation were present.

There was marked difference in the surface temperature of the two upper extremities (Table II), the right arm being the hotter.

Table I shows, as in the previous case, that the venous blood in the neighborhood of the arteriovenous communication contained so much oxygen as to be almost arterial.

Amputation was performed through the forearm. During the operation the bleeding from the numerous dilated veins was like that from arteries.

Dissection of the amputated part disclosed dilatation of both arteries and veins and multiple fistulæ between them (Figs. 6 and 7). The condition is also well shown by roentgenographic examination after the injection of a solution opaque to roentgen rays

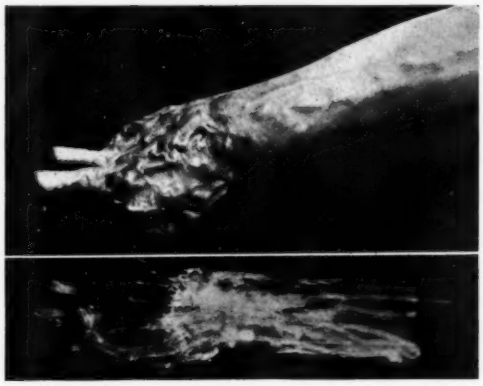

Fig. 4 (above). Dilated and tortuous vessels on dorsum of hand and forearm (Case 5).

Fig. 5. Amputated arm after injection of barium solution (Case 5).

(Fig. 5). The solution returned almost immediately through the cut ends of the vessels and after it had congealed, a roentgenogram was made. It is of interest to note that, while the solution fills the dilated proximal arteries and veins, the more distal vessels are only partially filled because of the short-circuiting due to the fistulous communications.

Since the operation, the local physician reports that the patient's condition is excellent.

CASE 6. A man, aged 24 years, came to the Mayo Clinic in 1922. Ever since he could remember, his right foot had been larger than the left. In 1909, an ingrowing great toe nail of the right foot was operated on; it became infected, and for 4 years constantly drained pus, the toe eventually turning black. In 1913 there was a sudden hæmorrhage from the dorsum of the right foot near the metacarpophalangeal joints; the bleeding was stopped by binding the foot. The great toe was amputated in 1914, and since that time there had been several hæmorrhages. The patient had noticed that the right foot was much swollen and he felt pulsations in the foot, leg, and thigh. An ulceration on the dorsum of the right foot still persisted. A year before the patient's admission to the Clinic, the foot was operated on, and the anterior and posterior tibial vessels were probably ligated.

All the superficial veins of the right leg were greatly dilated (Figs. 8 and 9). The great toe was absent and there were chronic ulcerations on the dorsum of the remaining toes. Thrills and bruits were present from Poupart's ligament distally as far as the toes. The right foot felt like a mass of spongy tissue. Pressure over the internal saphenous vein immediately caused the foot to swell. There was a loud, blowing, systolic, apical murmur, and the lesion of the heart was diagnosed as chronic mitral endocarditis with regurgitation (as the patient gave a history of previous rheumatic fever, the condition of the heart

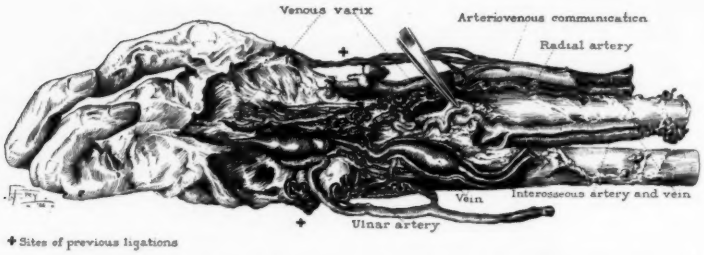

Fig. 6. Dissected specimen; volar aspect; tortuosity and dilatation of blood vessels with arteriovenous anastomoses (Case 5).

could not be attributed to the adverse effects of the state of his leg). Roentgenograms of the heart did not show enlargement. The bones of the foot were normal by roentgenogram. The systolic blood pressure was 130 and the diastolic, 70; the pulse rate was 80.

At the first operation, May 4, 1922, the anterior tibial artery and the veins on the dorsum of the foot were ligated. The artery just proximal to the transverse crural ligament was dilated to a diameter of about 3.7 centimeters and its wall markedly thinned. The arteriovenous communications could not be located definitely.

At the time of the second operation, July 20, the bruit and thrill still extended above the popliteal space; the leg was amputated in an attempt to preserve a useful stump. All veins were markedly enlarged, some to a diameter of 3.75 centimeters.

The patient was examined August 16 and the condition of the leg found to be satisfactory; the veins were not enlarged as before the operations and no thrill could be felt or bruit heard.

Case 7. A woman, aged 24 years, came to the Mayo Clinic, January 26, 1923. Twenty-five months before, she had noticed a swelling on the chin; the swelling had gradually enlarged and for a while had had a bluish tinge which disappeared later. There had been no associated pain.

There was a pulsating irregular tumor on the chin to the left of the median line and extending downward so as to encroach on the submental region. The tumor measured approximately 7.5 by 5 by 2.5 centimeters. It was soft and a definite thrill was palpable. The systolic blood pressure was 118 and the diastolic, 82; the pulse rate was 88. The heart was normal.

Operation was performed January 30. The left external carotid artery was ligated and the size of the tumor and the force of its pulsations were immediately reduced. The right external carotid was ligated February 6. The aneurism was dissected and several dilated veins ligated February 13.

November 4, 1925, the patient returned with a recurrence of the original lesion. She said the tumor had continued to enlarge during the last 4 or 5 months. At operation, November 11, a pulsating indefinite mass, about 4 by 3 by 2 centimeters in size, which lay superficial to the anterior belly of the digastricus muscle was removed. There was a moderate amount of bleeding. The pathological report was hæmangioma.

The patient returned in May, 1926, with slight fullness on the right side of the chin; a slight thrill was perceptible. Radium treatment was advised.

Case 8. A girl, aged 16 years, came to the Mayo Clinic to have the condition of her left foot investigated. Her mother stated that from the time the patient was a baby, the left foot had not seemed quite normal and when the child reached the age of 8 years, this foot had seemed to be hotter than the other. Three years later small scabs began to appear on the dorsum of the toes, gradually increasing in size and accompanied by a discharge of greenish pus. Because of the spread of the ulcerous area the outer four toes were amputated in March, 1924. The girl was told at that time that she was suffering from tuberculosis of the foot. On account of a similar condition of the great toe this remaining digit was amputated the following November.

All the toes of the left foot had been amputated, the stump was swollen and cyanosed and near the medial side of the distal end was a scab-covered sinus which had persisted since the first operation (Fig. 10). The foot was unduly hot. Posterior to the internal malleolus was an area about 3 centimeters in diameter over which a distinct thrill, synchronous with the pulse, was palpable. On the dorsum of the foot, a similar thrill could be felt over a larger area. On auscultation of these areas a loud, continuous bruit, with exacerbations corresponding to the systole of the heart, was heard. This bruit, although of maximal intensity over these areas, could be heard as far proximally as the middle of the calf. The legs were equal in length. The heart was not enlarged and the first mitral sound was accentuated. The systolic blood pressure was 120, and the diastolic, 80. The pulse rate was 80. Roentgenographic examination of the foot showed that all the toes had been amputated through the middle of the metatarsals, but lesion of the bones was not discernible.

Calorimetric studies were made with the Stewart-Kegerries foot calorimeter to determine the heat emission of both feet (Table III).

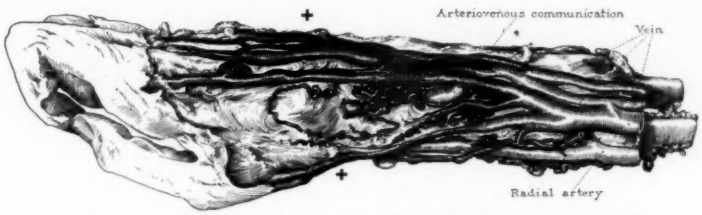

Fig. 7. Dorsal aspect of dissected specimen shown in Figure 6 (Case 5).

It will be seen that the left foot was emitting nearly 12 times as much heat as the right.

Table IV shows that from the knees downward the temperature of the left leg became progressively higher than that of the right; the maximal difference was attained at the heel, 5.2 degrees C. (8.6 degrees F.).

In this condition one would expect to find the oxygen content of the venous blood in the vicinity of the arteriovenous communication varying greatly from normal (Table I). Thus the venous blood from the affected (left) foot contained more than four times as much oxygen as that from the right, and consisted of nearly pure arterial blood. The total volume of whole blood was found to be 106 cubic centimeters for each kilogram of body weight.

June 26, the dorsalis pedis and posterior tibial arteries in the left foot were ligated. In consequence of this procedure, the foot appeared to improve for a short time. July 7, it was seen that the total volume of whole blood was 88 cubic centimeters for each kilogram of body weight; this was a marked decrease. After a few weeks the foot began to cause pain again and the scab-covered sinus at the distal end of the foot did not show any signs of healing. The patient returned and the foot was amputated.

Pathologically this seems to be a case of multiple aneurismal varicose or cirsoid aneurism.

TABLE III.—CALORIMETRIC STUDIES OF BOTH FEET SHOWING THEIR MARKED DISSIMILARITY OF HEAT EMISSION, CASE 8

Date	6-18-25
Blood Pressure	
Systolic	120
Diastolic	80
Pulse	80
Temperature (°C.)	
Outdoor	24.2
Room	23.8
Right foot	
Total calories for 10 minutes	680
Surface area (square inches)	92
Calories for each minute for each square inch	0.73
Left foot	
Total calories for 10 minutes	7100
Surface area (square inches)	82
Calories for each minute for each square inch	8.65

CASE 9. A boy, aged 6 years, was first seen in June, 1921. He was quite well until the previous November, when the parents noted slight puffiness of the left upper eyelid. Shortly afterward they noted pulsation in the region of the inner canthus, and then a distinct bruit over different parts of the head.

The patient was well nourished. There was slight exophthalmos of the left eye with some congestion of the conjunctival blood vessels. Pulsation was visible and a bruit, of maximal intensity, over the left temporal area, could be heard over the whole skull. Pressure on the left common carotid artery reduced both thrill and bruit considerably. The heart was normal. The systolic blood pressure was 108, and the diastolic, 52; the pulse rate was 98. Examination of the fundus disclosed bilateral choked disc. At operation, July 1, the left common carotid artery was ligated just below its bifurcation. In May, 1923, there was no marked change in the patient's condition, the exophthalmos, pulsation, and bruit still persisting.

The main points of interest in the nine cases are summarized in Table V.

ETIOLOGY

The studies of Sabin and Woollard appear to explain the occurrence of these arteriovenous communications on an embryological basis, since both arteries and veins arise through differentiation from a common capillary plexus. Sabin finds that in certain embryological vessels, the direction of the flow of

TABLE IV.—SURFACE TEMPERATURE OF FEET AND LEGS MEASURED AS FAR AS POSSIBLE OVER CORRESPONDING AREAS, JUNE 17, 1925; ROOM TEMPERATURE 23.8 DEGREES C.

Area	Temperature° C. Right	Left
Heel	25.6	30.8
Dorsum of foot	27.5	32.3
10 cm. intervals proximally		
1	29.2	32
2	29.3	31.9
3	30.2	31.4
4	30.5	31.8

Fig. 8 (above). Dilatation of superficial veins and chronic ulceration of toes (Case 6).
Fig. 9. Inner aspect of leg showing dilated veins (Case 6).

blood may be reversed so that these vessels which function as arteries during one stage of development function as veins during another; she mentions the subintestinal artery and the vena capitis medialis as examples. Woollard's diagrams show clearly the capillary network through which the forelimb bud of the pig embryo first gets its blood supply and how, at a later period, when the subclavian artery and vein are beginning to be differentiated, there are multitudinous communications between the two vessels. Because of this state of affairs existing in the embryo, Reid (17) aptly expresses wonder that congenital communications between arteries and veins do not occur more frequently.

This embryological explanation also satisfactorily accounts for the multiple communications usually found in congenital cases, in contrast to the single communications usually present when the etiological factor is trauma. It is interesting that Reid, in his congenital case of arteriovenous fistula between the subclavian vessels, found that the artery and vein were each connected with the intermediate mass of dilated veins by a single vessel.

SITE OF OCCURRENCE

Whereas an acquired arteriovenous fistula may be situated anywhere in the body, depending on the part traumatized, congenital cases are somewhat more limited in their distribution, the vessels of the trunk apparently being only rarely, if ever, affected, although Hewett diagnosed the lesion in his case as intra-abdominal. This is the only example of the congenital type affecting the vessels of the trunk which has come to our notice. An analysis of our cases shows the sites of occurrence to be: head 3 (scalp 2, intracranial 1), neck 2, and extremities 4. Of Reid's 5 cases, 4 were in the head and neck (2 intracranial) and only 1 was in the extremities. It would seem, therefore, that the commonest sites of occurrence of congenital arteriovenous fistulæ are the head, both extracranial and intracranial, and neck, while the extremities come next in order of frequency.

THE EFFECTS OF ABNORMAL ARTERIOVENOUS COMMUNICATIONS

The usual effects of arteriovenous fistula in general may be considered from three aspects: (1) local, (2) regional, and (3) general or systemic.

The local effects are those manifested by the affected blood vessels. The blood from the artery flows into the distal part of the vein, greatly increasing the volume of blood in it and producing a pressure greater than the vein is normally capable of withstanding. As a result the vein becomes dilated and tortuous. Similar changes take place, though probably not to such a great extent, in the proximal part of the vein. The larger the fistula and the longer its duration, the more widespread will be the venous involvement, in many cases almost all the veins of a limb which is the site of a fistula being affected. Reid (15) found in experiments on dogs that there was an increase in the elastic tissue in the walls of an involved vein (the so-called arterialization). We were able to examine microscopically the veins in the vicinity of the anastomosis in one case only. We found no evidence of arterialization, but calcareous degeneration was well marked in the internal part of the middle coat in one section (Fig. 11).

The effect of an arteriovenous fistula on the involved artery consists of dilatation, thinning of its walls and degenerative changes in its coats, all these changes taking place, in greater or less degree, only proximal to the fistula. Holman (7) has drawn attention to

the fact that when the cross section of the fistula is small, these changes may be hardly noticeable or even entirely absent, although the fistula may have existed for many years, whereas when the fistula is large they are invariably present, particularly the dilatation and thinning, in marked degree. As to the cause of these changes in the proximal artery, opinions are somewhat divided. Some authors believe that the diminished blood pressure causes loss of tone and functional inertia which results in the changes just described. The objection to this theory is that the diminished blood pressure is general and, since other arteries are not affected, it would seem that the cause is local rather than general. Others take the view that the increased amount of blood flowing through the artery is sufficient to account for them. Reid (18) thinks that "it would be unusual if a simple handling of an increased volume of blood by the proximal vessels did not lead to an hypertrophy and strengthening of their walls." While it is true that dilatation, thinning, and degeneration of the walls of the hollow viscera are often the sequelæ of previous hypertrophy, yet this is not always so, and we offer another explanation of these changes. In the first place, the dilatation is acute; in support of this are the observations that it is present only when the fistula is large and that it occurs almost at once after the production of the lesion. Second, the dilatation causes constriction of the vasa vasorum, and this results in diminished nutrition of the vessel wall, leading finally to thinning and degeneration.

The regional effects are those evident in the particular limb affected. The first is: hypertrophy, as seen in the increased girth and length of the limb. The latter indicates an overgrowth of the bones and is found only when the lesion has been established for some time before the ossification of the epiphyseal cartilages, so that congenital cases are particularly liable to show it. The second effect is increase in superficial temperature, and the third, trophic changes. The first two can be explained by the increased volume of blood flowing through the limb consequent upon the production of the fistula. The trophic changes are produced by two factors: first,

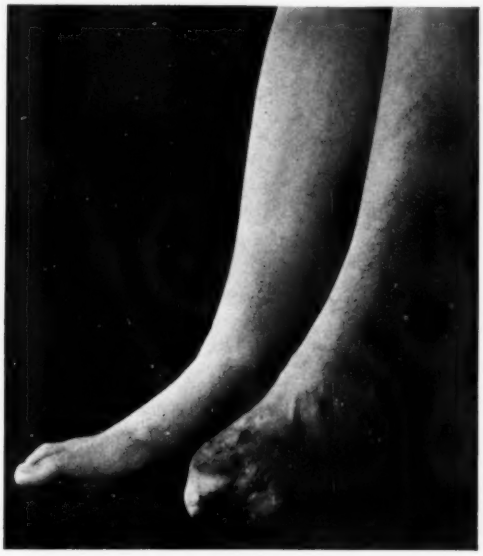

Fig. 10. Left foot shows swelling, amputation of toes, and scab covering the discharging sinus (Case 8).

the diminution of the flow of blood through the capillaries on account of its easier path of escape into the veins through the fistula; and second, the increased pressure on the veins impeding the return of deoxygenated blood from the capillaries. These two factors working together tend to bring about a state of anoxæmia of the tissues affecting more particularly those most distally situated. On this account, if these tissues become even slightly injured, the normal inflammatory reaction necessary for their repair is either feeble or absent, and hence chronic progressive ulceration (partial destruction) and later gangrene (total destruction) supervene. In Cases 3, 5, 6, and 8, that is, all those in which an extremity was affected, chronic ulceration and gangrene were quite prominent features.

The general or systemic effects depend on the upset in the function of the circulatory system produced by the development of the fistula, and also on nature's efforts at compensation. Normally the circulatory system consists of heart, arteries, capillary bed, and veins. The formation of an arteriovenous fistula creates a new path through which the

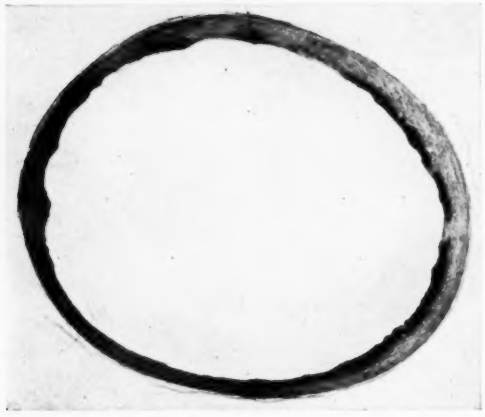

Fig. 11. Vein showing calcareous degeneration in inner part of middle coat (Case 5).

blood can flow, a second system consisting of heart, artery, fistula, and vein being thus formed. The essential point of difference between the two systems is that the second (fistulous) system is practically devoid of peripheral resistance. Since a fluid will always flow along the path of least resistance, the less the peripheral resistance of the fistulous system, the greater will be the tendency for blood to pass through it. In order that blood may still continue to flow through the capillary system with its high peripheral resistance, it is essential that an adequate general blood pressure should be maintained (Holman, 7).

The systemic effects may be considered from three aspects: (1) peripheral resistance and blood pressure, (2) total volume of circulating blood, and (3) the reaction of the heart.

While systolic pressure is chiefly maintained by cardiac output, diastolic pressure on the other hand is largely maintained by the elastic recoil of the arteries against the peripheral resistance. Following the production of a fistula the peripheral resistance is much diminished. Thus in arteriovenous fistula one would expect a normal or nearly normal systolic pressure and a low diastolic pressure, with consequent increase in pulse pressure. These are usually found, particularly in cases of the traumatic type. In our 9 congenital cases, a low diastolic pressure was noted only in 3 (Cases 3, 5 and 9). On closure of the fistula (and therefore re-establishment of the normal peripheral resistance), the diastolic pressure rises to normal, while the systolic pressure usually remains about the same, although there may be a transient rise. Hoover and Beams reported that, on closure of the fistula, the systolic pressure rose by the same amount as the diastolic, but in most of the reported traumatic cases the systolic, as already mentioned, remains the same or rises only a few points. As multiple anastomoses are present in congenital cases, these changes in blood pressure are difficult or impossible to elicit because of the difficulty of closing all the fistulæ simultaneously.

Holman has pointed out that because of the easier path of escape offered to the blood from the arterial system by an arteriovenous fistula, the amount of blood passing through the system, heart, arteries, capillaries, and veins, is reduced according to the size of the fistula; that in order that the supply of blood through this system will be sufficient for the needs of the body, an adequate general blood pressure must be maintained, and that one of the compensatory mechanisms to insure this is an increase in the total volume of the circulating blood. He proved his theory to his complete satisfaction by experiments on dogs in which he had produced arteriovenous fistulæ, showing that when the lesion was small (and therefore the amount of blood short-circuited back to the heart was correspondingly small) the blood volume remained constant or nearly so, while with larger fistulæ he found a definitely increased blood volume together with changes in the heart and proximal vessels (9). Even admitting that the present methods for the determination of blood volume leave much to be desired, his results seem definite enough to be outside the limits of experimental error.

From a comprehensive study of blood volume (by the dye method of Keith, Rowntree and Geraghty) in health and disease, Brown and Rowntree do not regard the results obtained by present methods of estimation as absolute, but believe that for comparative work they are reliable. They have found that blood volumes between 70 and 100 cubic

centimeters for each kilogram of body weight may be regarded as normal for different healthy individuals. On the other hand, the blood volume in the same healthy individual estimated at different times under comparable resting conditions may vary as much as 5 cubic centimeters for each kilogram. The single case in our series (Case 8) in which the blood volume was determined before and after operation showed a fall from 106 to 88 cubic centimeters for each kilogram of body weight after ligation of the main arteries involved, a decrease greater than the normal variation. This single piece of clinical evidence, though supporting Holman's experimental results, does not justify any definite conclusions being drawn. However, we hope in due course to have the opportunity of studying blood volume in a sufficient number of cases to be able to satisfy ourselves as to whether the data in this single case can be satisfactorily corroborated or not.

In many of the cases reported in the recent literature on the subject, enlargement of the heart has been noted, sometimes accompanied by symptoms or signs of myocardial degeneration. Until comparatively recently it was thought that the heart condition was coincidental, and that, if the state of the heart was poor, the surgical risk was correspondingly great and operation contra-indicated. During the war, however, observers had the opportunity of studying a large number of cases and they began to recognize that the condition of the heart was not coincident with, but consequent on, the production of the fistula. One of the most striking cases is reported by Leriche. This surgeon extirpated an arteriovenous aneurism in a patient in whom considerable cardiac enlargement and general signs of cardiac decompensation were present; the heart returned to its normal size and the signs of decompensation disappeared. This case, together with later abundant experimental work and clinical investigation by the Americans, Holman (7, 8, 9), Matas, Reid (15, 16, 17, 18, 19), Hoover and Beams, and the Englishmen, Lewis and Drury, has completely proved the detrimental effect of abnormal arteriovenous communications on the heart. Opinions differ as to the cause of the cardiac enlargement. Lewis and Drury maintain that it is largely due to dilatation consequent upon faulty nutrition of the myocardium, the low diastolic pressure being insufficient to permit of adequate filling of the coronary vessels. On the other hand, Holman (8) in experiments on dogs found that in addition to dilatation there was an increase in the weight of the heart which he concluded must be due to hypertrophy. In our series, cardiac enlargement was only demonstrable in 2 cases (Cases 3 and 5). It did not occur in any of Reid's cases.

An arteriovenous fistula has been described as analogous to an aortic leak but, whereas in aortic regurgitation the left side of the heart alone undergoes dilatation and hypertrophy as a compensatory measure, in arteriovenous fistula, both sides of the heart undergo these changes, the right side on account of having to cope with the increased intake consequent on the abnormal escape of blood into the veins through the fistula, the left in order to increase output to maintain adequate general blood pressure. If Holman's contention be correct, in addition to these factors the heart has to deal also with increased total volume of blood.

Branham, in 1890, noted that in these cases closure of the fistula produced slowing of the pulse rate; this observation has since been spoken of as Branham's bradycardiac phenomenon. It could not be elicited in any of the congenital cases in this series, because of the difficulty in closing the multiple communications. When an arteriovenous fistula is closed, the blood has to flow through the circulation, heart, arteries, capillary bed, and veins, so that the peripheral resistance of the arterioles is again brought into play with resulting increased peripheral resistance and consequent raising of the blood pressure. The slowing of the rate of the heart is therefore in accordance with Marey's law, that the pulse rate varies inversely with the blood pressure. The mechanism by which the pulse rate is adjusted in this manner has long been regarded as reflex, it being thought that a rise in blood pressure, by stretching the wall of the aorta, stimulates the endings of the depressor nerve: as a result of this, the cardio-inhibitory center was thought to be excited and that the impulses

TABLE V.—CLINICAL MANIFESTATIONS AND TREATMENT OF CONGENITAL ARTERIOVENOUS ANEURISM

Case	Sex and age	Lesion	Evidence of cardiac change	Pulse	Blood pressure		Trophic changes	Date of operation	Type of operation	Dilated proximal artery	Result	Remarks
					Systolic	Diastolic						
1*	23 F	Cirsoid aneurism right side of head and neck	Systolic murmur at apex.	84	116	80	None	8–3–16	Ligation of right external carotid	−		Recovered from operation but died later from other causes
								8–11–16	Excision of cirsoid aneurism			
2	10 F	Arteriovenous aneurism, orbit and brow	None	....	115	74	None	2–12–18	Ligation of right external carotid	−	Well	
3	15 M	Arteriovenous aneurism, probably of subclavian vessels	Heart enlarged	72	114	56	Right arm swollen and hypertrophied; marked engorgement	6–19–19	Ligation of right ulnar artery.	+	No benefit	Gangrene of right little finger later.
								7–29–19	Ligation of right radial artery		No benefit	Right arm amputated at shoulder in February, 1925 (elsewhere).
4	21 M	Cirsoid aneurism of scalp	None	100	140	110	None	2–23–21	Dissection of arteriovenous aneurism	−	Cured	
5	27 M	Arteriovenous aneurism, cirsoid type, right forearm		80	Right		Hypertrophy of right arm	2–6–22	Excision of arteriovenous communication between ulnar artery and vein	+		Atrophy and gangrene of the distal phalanges later necessitated amputation of 2 fingers. Pulsation of vessels markedly diminished.
					130	42						
					Left							
					102	60						
								3–15–22	Excision of arteriovenous communication between radial artery and vein			
			Heart markedly enlarged	85	120	80	Trophic ulcers of right hand	6–22–25	Amputation middle of forearm	+	Well	
6	24 F	Arteriovenous aneurism of right foot	Left ventricular hypertrophy and mitral lesion	80	130	70	Ulcers on dorsum of right foot	5–4–22	Ligation of tibial artery and vein	−		
								7–20–22	Amputation at juncture of upper and middle thirds of right leg		Well	
7	24 F	Submental cirsoid aneurism	None	92	150	78	None	1–30–23	Ligation of left external carotid	−		
								2–6–23	Ligation of right external carotid.	−		
								2–13–23	Dissection of aneurism		Well	Three years later mass diminished; still slight pulsasation in submental region.
								11–11–25	Dissection of aneurism.			
8	16 F	Arteriovenous aneurism, cirsoid type, left foot	None	80	120	80	Trophic ulcers of toes	6–26–25	Ligation of dorsalis pedis and posterior tibial arteries.			
								10–8–25	Amputation of left leg.		Well	
9	6 M	Intracranial arteriovenous aneurism with pulsating exophthalmos of left eye	None	98	108	52	None	7–1–21	Ligation of left common carotid		Slightly improved	Two years later no marked change in condition. Bruit and exophthalmos still present.

*Case 1 believed to be of congenital origin; aggravated by accident at age of 10 years.

from this center, by way of the vagi, brought about a reduction of the pulse rate. In this connection we would like to draw attention to the recent work of Anrep and Starling, which seems to necessitate some modification of this view of the reflex causation of the phenomena on which Marey's law is based. In the experiments they used a method in which, by means of a heart-lung preparation, the circulation through the brain of an animal is entirely under the control of the experimenter, while the animal's own heart supplies only the trunk and limbs. By such an arrangement the circulation through the vasomotor and cardio-inhibitory centers is entirely unaffected by changes in the action of the heart or in the circulation through the trunk and limbs. The nervous connections between the brain and the heart of the same animal were undisturbed. It was found that, when the pressure in the brain was raised, the heart was slowed if both vagi were intact, but not if they were divided; but rise of blood pressure in the animal's own aorta caused no such reflex alteration in the rate of the heart beat whether the vagi were intact or not. The slowing expressed as Marey's law therefore would seem to be explicable not by reflex through the fibers of the depressor, as has been commonly supposed, but by the direct effect of the raised arterial pressure on the cardio-inhibitory center.

In cases of arteriovenous fistula, the diastolic pressure is lowered while the systolic is practically unchanged; thus the mean arterial pressure is lowered. This no doubt accounts for the increased pulse rate observed both clinically and experimentally in these cases in accordance with Marey's law. A pulse rate above 80 was noted in 5 of our cases (Cases 1, 3, 5, 6, and 9).

TREATMENT

Surgery provides the only effective treatment of congenital arteriovenous aneurism. In order to treat successfully any arteriovenous aneurism, the abnormal communication or communications between the arterial and venous circulation must be permanently broken. To accomplish this, the fistulous tract must be destroyed by excision or division, or its lumen obliterated as by ligation or clotting, or the fistula or fistulæ, including segments of the adjacent arteries and veins, must be isolated from the circulation as by multiple ligation of the artery and vein.

There are reports of numerous cases of traumatic arteriovenous aneurism, both experimental and clinical, in which spontaneous clotting and subsequent healing have occurred under non-operative management. Nearly all of these aneurisms have a small fistulous tract and are of recent development, usually within 2 or 3 months; but there is no justification for non-surgical measures in any case of arteriovenous aneurism which has lasted 6 months or longer in the reasonable expectation of causing the fistula to heal. In the congenital arteriovenous communications, success from non-surgical measures, such as injections of anticoagulants, cautery puncture, and irradiation, is limited to the occasional small nevus or pulsating hæmangioma. In all others, cure is effected only by radical surgical measures.

In the main, the symptoms of congenital arteriovenous aneurism are similar to those of the traumatic type, yet the treatment of the former presents inherent problems that are not often encountered in the acquired aneurism. The additional difficulties in treatment arise from the differences in the pathological anatomy. In the traumatic type, the communication, established in most cases by a penetrating wound, is usually single and often involves the larger vessels accessible to surgical approach. Here the problem is restricted to checking the arterial leak without interfering with the blood supply of the tissues beyond. With the diversion of part of the arterial blood through the leak, the blood supply of the tissues distal to the fistula becomes impaired. Collateral circulation is thereby stimulated and invariably becomes well established, so that the choice of any of the several accepted operative procedures may be selected, usually without fear of gangrene of the extremity.

The operative procedures which are of approved worth in the treatment of arteriovenous aneurisms include: (1) excision of a segment of the affected artery and vein including the fistulous tract; (2) isolation and ligation of the fistulous tract with silk; (3) restorative angiorrhaphy, which may be accomplished by one of

three methods: division of the fistula and lateral suture of the opening in the artery and vein, the Matas-Bickham transvenous method of closure of the fistula, and endo-aneurismorrhaphy (Matas), in certain cases of varicose aneurism; and (4) quadruple ligation of the artery and vein proximal and distal to the aneurism.

The operation of ligation of the proximal artery alone is mentioned only to condemn it as an obviously unsound procedure, suitable for only one type of arteriovenous aneurism: the intracranial lesion of carotid-cavernous-sinus fistula, or pulsating exophthalmos. When the proximal artery alone is ligated in the case of an arteriovenous aneurism involving important vessels of an extremity, the blood supplied to the parts distal to the anastomosis by way of the arterial collaterals will flow in the direction of least resistance, that is, in a retrograde manner through the distal artery by way of the fistulous opening back to the heart. The greater part of the collateral circulation will then be shunted back to the heart without furnishing adequate nutrition to the extremity; thus trophic sores or gangrene become inevitable.

In cases of intracranial arteriovenous fistula, direct attack on the fistula is impossible. Experience has proved that a great many of these involving the internal carotid and the cavernous sinus, particularly those of traumatic origin, are ameliorated and frequently cured by proximal ligation of the internal carotid. In such instances the communicating tract must be small to favor closure by clotting. But even so, it is difficult to understand how cure is effected unless it is that the slowing of the blood stream through the fistula incident to the ligation of the carotid is more marked than usual. This might be explained by the additional obstruction to the flow offered by the trabeculations in the cavernous sinus, permitting clotting in the fistulous tract to occur before the secondary rise in blood pressure in the distal carotid after the re-establishment of the collateral circulation.

The one recorded case of a congenital arteriovenous aneurism with a single communication is that of Reid, already referred to. In this instance, the difficulties encountered made it necessary to perform the operation in two stages, and to apply 10 ligatures to important arteries and veins to bring about cure. However, in most cases of congenital arteriovenous aneurism there are multiple communications between the arteries and veins, often between the small branches. This fact materially complicates the treatment, for, to effect a cure, not one but all of the communications must be destroyed. The treatment, therefore, must be directed at the extirpation of the mass of dilated vessels and their communications as in superficial cirsoid aneurisms, or the affected limb must be amputated. In 3 cases in this series in which a limb was involved, a maximal thrill could be felt over one of the larger arteries, which suggested that the communication was single, and an operation was advised with the view of extirpating the fistula. After exposure of the vessels a definite anastomosis between the artery and its two venæ comites was found and extirpated after both artery and veins had been sacrificed. Following this procedure, however, in each case the circulation in the distal part was definitely diminished, gangrene resulted, and amputation of the limb became necessary. Subsequent radiological examination and dissection of two of these amputated limbs showed, scattered diffusely through the limb, numerous communications between the arteries and veins, many of only minute dimensions, the presence of which precluded the possibility of any effectual surgical treatment of the anomaly, other than by amputation.

The time to institute radical operation should of necessity vary with each patient; the site and the rapidity of the growth of the lesion, the degree of local disability, and the presence or absence of systemic changes should be taken into consideration in making the decision. It is conservative surgery to extirpate the superficial arteriovenous aneurism in early life before extensive growth takes place; otherwise more radical measures resulting in more marked disfigurement will be necessary. In the absence of cardiac changes, amputation of the limb for congenital arteriovenous aneurism, involving the deeper vessels of an extremity, can be safely deferred until inconvenience and disability demand it.

CONCLUSIONS

1. A consideration of the congenital cases reported establishes the following points of difference between them and those of the acquired type: (a) there were multiple communications between arteries and veins, as opposed to the single communication usually obtaining in traumatic cases; (b) while the local and regional effects were similar to those found in the acquired type, the general effects were not nearly so well marked; and (c) the effects of the congenital form were produced much more slowly. It would seem that these last two observations may be attributed to better adaptation of the cardiovascular mechanism when the abnormal condition exists from birth.

2. The head and neck are the most common sites of occurrence, the extremities coming next in order of frequency. The vessels of the trunk are rarely, if ever, affected.

3. On account of the frequent presence of multiple communications and the progressive nature of cases of the congenital type, they are more liable to necessitate radical amputation than are the acquired cases.

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THE DISTAL ANTERIOR CLOSED SPACE INFECTION

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FOR many years, Kanavel (3) and Auchincloss (1) have stimulated assistants and students to a better understanding of hand infections. There are many fundamental surgical principles which can be brought out while teaching the distal anterior closed space infection. Although designated as a minor surgical condition, it frequently terminates as a major problem both for surgeon and patient. The discomfort, loss of time, and occasional deformity which result make it evident that early recognition and proper treatment of this infection are necessary. "Felon" as a synonym has been discarded in this paper, because as this term is generally used it may signify an involvement of too many other adjacent anatomical spaces or structures.

Industrial surgery has made possible the accumulation of many hand and finger cases for statistical purposes. In one insurance company (5), 65 per cent of all the hand cases were found to be due to infections following small injuries, and the remaining 35 per cent included fractures, lacerations, and crushing injuries. The combined statistics of 5 other insurance companies show that 15 per cent of their cases were treated for injury of the hand and that one-fifth of these had infection. The latter caused 75 per cent of serious deformities of the hand (2).

In order to get certain specific data on the condition under discussion, 45 consecutive ambulatory cases were studied at the Presbyterian Hospital according to a distinct scheme, as seen in the accompanying table. It must be understood that accurate conclusions cannot be drawn from these statistics alone. There are so many variable factors, that definite impressions acquired from experience with hundreds of other cases should not be excluded.

THE ANATOMY

A careful study of the anatomy (Figs. 1 and 2) is essential to an understanding of the pathology of this infection. The distal anterior closed space is a confined small compartment on the volar surface of the finger. It extends from the distal crease to the tip. Posteriorly it is bounded by the volar aspect of the phalanx, and laterally by fibrous tissue septa which separate it from the paronychium. It contains the following structures: fat pads, fibrous tissue septa, blood vessels, nerves, sweat glands, lymphatics, periosteum, and the insertion of the tendon of the flexor profundus digitorum at the proximal end of the distal phalanx. The flexor tendon sheath begins at the base of the distal phalanx and is included in the distal anterior closed space. It does not completely surround the tendinous insertion. The glands are superficial and quite numerous, Klapp and Beck (4) having demonstrated them even near the periosteum.

The fibrous tissue septa, strong, penetrating connective tissue fibers, run radially and centripetally from the thick skin and corium to the periosteum. This latter is composed of two layers, an outer, which has loose connective tissue fibers, and an inner, with a considerable amount of elastic tissue running in parallel bundles close to the bone.

The blood vessels of the inner layer are smaller than those of the outer layer and are intimately connected with the bone marrow by perforating arteries. The blood vessels enter the cortical bone through the haversian and Volkmann's canals and anastomose with the vascular system of the bone marrow. The fibers of Sharpey (periosteal prolongations into the bone) end in the interstitial lamellæ. The terminal portions of the digital arteries, lying anterolateral to the distal phalanx, are the primary trunks for the blood supply of the space and bone. The epiphysis receives its blood supply from a small independent volar digital branch which is given off on either side of the base of the phalanx before the main digital branch enters the closed space. The venous return from the bone marrow is chiefly through the vein emerging

from the nutrient foramen, usually situated on central part of volar aspect of the phalanx.

The superficial lymphatics form a diffuse network and drain proximally into the axilla. Roux (6) believes that there are lymphatics which run perpendicularly from the skin to the periosteum. These have not been definitely demonstrated. The phalanx is composed of a terminal tuft which is cortical bone, a diaphysis with its medullary cavity, and a proximal epiphyseal portion which is also cortical bone.

ETIOLOGY

It must be remembered that these cases were studied in a general hospital. They were most frequent in the second and third decades and were divided about equally between the sexes. Manual laborers and housewives were in preponderance. In the vast majority of cases the patient remembered a prick in his finger from a sharp object, such as a pin, a bone, or a splinter. In other instances there was a history of a superficial abrasion, a cut, a slight burn, or a continued contusion. Many times a trauma is not recalled.

PATHOLOGY

With the introduction of bacteria either directly or through the lymphatics, the infection may be originally superficial and then spread to the deeper parts, or it may take its inception in the deeper parts first. In the former case a small pustule is formed, the contents of which travel along the path of least resistance, perpendicularly or obliquely downward between the fibrous tissue septa, and into the fat pads. After they reach the comparatively avascular fatty tissue, fat necrosis takes place. In the early stage of the infection, there is no free pus. Most frequently the superficial pustule and the deeper necrotic area are larger in diameter than the sinus that connects them, hence the familiar name, "collar button" infection (Fig. 3). The infection may start at the tip of the finger and burrow directly backward, hugging the tip or volar aspect of the phalanx, or it may start directly in the center of the closed space, laterally or proximally. The statistics compiled from our 45 cases show that the majority of the infections occur distally.

The infecting organisms in their order are the staphylococcus aureus and albus, the streptococcus, the colon bacillus, and, as a contaminant, the pyocyaneus. Human bites cause a mixed infection which also yields anærobes. Cases infected with pneumococcus, gonococcus, and diphtheria bacillus have been reported (4). The reaction from these organisms is generally the same in this infection as in most parts of the body. Thus, the staphylococcus is prone to produce much pus and slough, while the streptococcus gives a great deal of pain with lymphangitis.

The phalanx may become involved in one of three ways: first, by infection carried through the lymphatics which run perpendicular to the bone and underneath the periosteum; second, by thrombosis of the blood vessels supplying it subsequent to the marked increase in pressure in the confined space; (3), by direct spread of the infection to the medulla through the nutrient foramen. The treatment of this complication, to be discussed later, is based on the fact that no involucrum, such as is formed almost everywhere else in the body, develops in this bone. Klapp and Beck (4) have expressed a thought in this connection that seems correct. Ordinarily, osteomyelitis begins in the medulla, and the pathological process spreads to the cortex and periosteum through the haversian systems. In this way the periosteum is stimulated and subsequently an involucrum forms. In the distal phalanx, on the contrary, the periosteum is the first to suffer severely. Regeneration therefore cannot take place until the sequestrum has been removed, to allow subsequent periosteal and endosteal growth.

SYMPTOMS AND SIGNS

After the introduction of bacteria into the tissues, the patient usually begins to have pain within the first 24 hours. It becomes throbbing in character and usually causes a sleepless night. Elevation of the finger and hot soaks may give relief. With the breaking down of tissue the pain usually becomes less. The constitutional symptoms as a rule are not very marked; chills and high temperature seldom occur. In the earlier stage, the end of the finger is tense and subsequently there

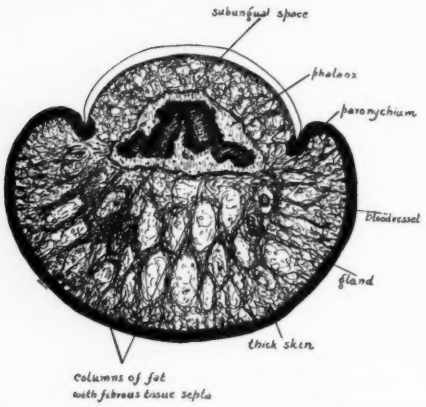

Fig. 1. Vertical cross section through the distal anterior closed space. (Adapted from Kanavel.)

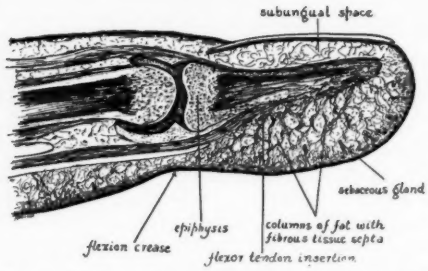

Fig. 2. Horizontal cross section through the distal anterior closed space. (Adapted from Kanavel.)

may be a brawny induration but rarely fluctuation. Swelling, redness, heat, and exquisite local tenderness are marked. The digital vessels can be felt to pulsate with greater force. If the infection has collar-buttoned, the top of the blister may be seen intact, or, in those cases in which there has been extensive liquefaction, open and exuding pus. There may be a great deal of swelling of the paronychium and eponychium. This frequently causes an incorrect diagnosis and results in many unnecessary incisions. There is usually slight interference in motion of the distal phalangeal region. Lymphangitis is not common and when present may indicate a severe infection. All these symptoms and signs vary with the pathological involvement. Erysipeloid with its redness and occasional tenderness must not be mistaken for this infection.

COMPLICATIONS

Those complications will be considered which occur in neglected cases which have not been treated surgically. The most frequent is osteomyelitis in which the method of bone involvement has already been discussed. The tendon may become involved, but rupture of the infection into the tendon sheath is very unusual. There seems to be a distinct walling off process of the sheath, and its comparatively good blood supply may be a factor in its preservation. Later, the interphalangeal joint may be affected and subsequent to this a localized tenosynovitis or an involvement of the dorsal subtendinous or dorsal subaponeurotic spaces may result. Rupture of the infection into the eponychium and paronychium or subungual space occurs infrequently. There may be a direct extension underneath the crease to the middle anterior closed space. From this point a lymphangitis with its subsequent sequellæ are frequently seen. Thrombophlebitis, sepsis, or metastatic pus foci occasionally occur. A detailed account of the paths of extension of infection has been given by Auchincloss (1).

PROGNOSIS

The prognosis in cases treated early and properly is good, and the average duration of treatment until complete closure of the wound is about 3 weeks. In cases reporting late for treatment, or in those improperly treated, or in those having constitutional conditions such as arteriosclerosis, diabetes, and syringomyelia, the various possible complications make the prognosis for the time of disability and end-result inaccurate.

TREATMENT

Conservative treatment rarely produces a good result, and should ordinarily be discouraged because it is likely to prolong disability and unnecessary suffering. The removal of the top of the blister in a low-grade infection in case there is involvement of only a very small amount of fat occasionally produces a cure. In the average case, when the diagnosis has been established, surgery is immediately indicated. It is unfortunate that

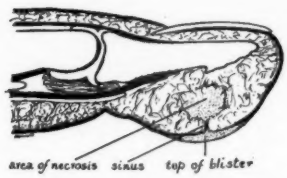

Fig. 3. Scheme of a typical collar-button abscess.

TABLE I. ANALYSIS OF FORTY-FIVE DISTAL ANTERIOR CLOSED SPACE INFECTIONS

	Number	Per Cent
Age		
Under 1	1	2.2
11 to 20	10	22.3
21 to 30	15	33.3
31 to 40	8	17.8
41 to 50	7	15.5
50 to 60	4	8.8
Sex		
Male	22	48.8
Female	23	51.2
Occupation		
Manual labor	23	51.06
Domestic	16	35.50
School	5	11.00
Infant	1	2.20
Type of wound		
Needle puncture	11	24.40
Unknown	10	22.20
Splinter puncture	9	20.00
Incised wound	6	13.30
Burn	3	6.60
Abrasion	3	6.60
Contusion	2	4.40
Secondary infection	1	2.20
Location of focus		
Distal	13	28.86
Lateral	12	26.64
Central	11	24.42
Unknown	5	11.00
Proximal	4	8.88
What appeared first		
Pain	35	77.80
Swelling	8	17.80
Blister	2	4.40
Incubation time for pain		
Unknown	14	31.08
First 24 hours (immediate, 2)	12	26.60
1 to 3 days	10	22.20
3 to 7 days	5	11.10
1 to 2 weeks	3	6.60
More than 2 weeks (7 weeks)	1	2.20
Time after pain has started that relief was sought		
3 to 7 days (most on fifth day)	25	57.70
1 to 3 days	17	37.74
10 days	1	2.20
Unknown	1	2.20
X-ray findings		
Not indicated	38	84.36
Extensive osteomyelitis	3	6.66
Beginning osteomyelitis	2	4.44
No X-ray	2	4.44

Fig. 4. A half elliptical incision divided into its components—lateral, bilateral, and hockey stick.

Anæsthesia		
General	32	71.04
Local	13	29.96
Type of incisions		
Bilateral	18	39.96
Lateral	9	17.60
Horseshoe	6	13.32
Hockey stick	5	11.10
Hockey stick long	3	6.66
Hockey stick transverse	2	4.44
Spontaneous rupture	1	2.22
Culture		
Staphylococcus aureus hæmolyticus	32	17.04
Staphylococcus aureus	6	13.35
Unknown	4	8.88
Staphylococcus albus	1	2.22
Streptococcus hæmolyticus	1	2.22
Gross pathological findings		
No pus	2	4.40
Few drops to 1 c.cm.	24	42.18
1 c.cm. to 5 c.cm. and slough	9	19.98
12 c.cm.	1	2.20
Collar button abscess	3	6.66
Necrosis of bone	3	6.66
Involvement of mid-space	2	4.44
Subungual abscess	1	2.20
Length of drainage		
48 hours	30	66.60
No drain	4	8.80
24 hours	4	8.80
72 hours	2	4.40
3 to 7 days	5	11.1

Postoperative complications
Most cases had none. The most frequent is osteomyelitis.

Postoperative sequelæ
Most cases had none. The minority had epithelial clefts.

Time disability
Average disability, 23 days; lowest, 6 days; longest, 5 months.

End-results
Most that could be followed were good. The others had epithelial clefts, clubbing, and stubbing of finger, disturbances in sensation, loss of substance, or distortion of terminal phalanx.

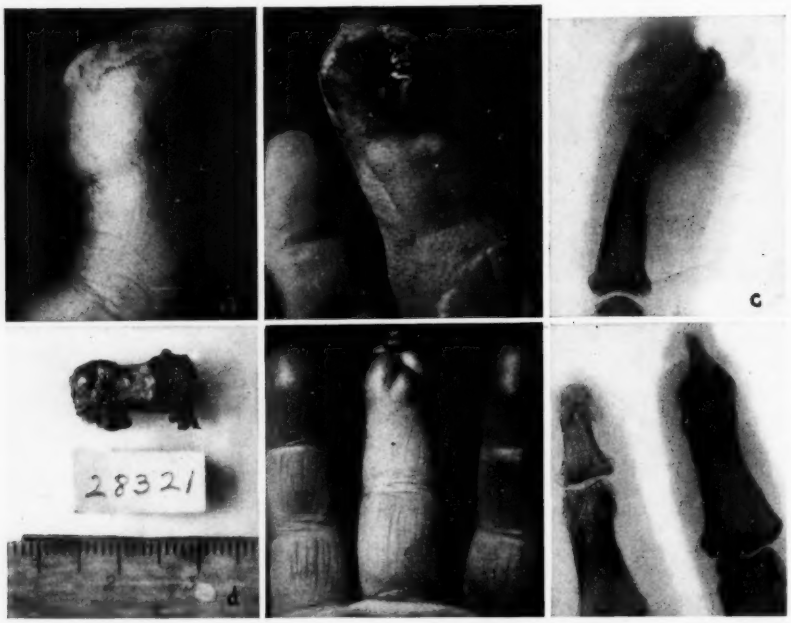

Fig. 5. Case No. 109255. a, A distal anterior closed space infection of the thumb. b, Case No. 109657. Appearance of distal anterior closed space infection with complicating osteomyelitis 26 days after operation. c, Roentgenogram of same finger as in Figure 5b. Note involvement of bone down to epiphysis. d, Appearance of phalanx of same finger after removal. e, Unusual end-result after 26 months, showing epithelial cleft, loss of substance, stubbing and clubbing of the finger and incurvation of the nail. f, Roentgenogram of terminal phalanx of finger shown in Figure 5e. Note the stunted and conical phalanx produced by the extreme contracture of the overlying soft parts.

relief for the condition is usually sought rather late. From our own statistics, about 57 per cent of the cases reported for relief from 3 to 7 days after pain began, and most of the others between 1 and 3 days after. A frequent error is an attempt to "draw out" the pus with poultices, hot soaks, or the "black salve" (ichthyol) which the corner druggist has given the patient. Removing the top of the blister or pricking it with a needle and squeezing out pus is another common practice. Clearly, with such treatment the necrotic fat pads do not receive proper drainage, and if relief is obtained at all it is only temporary. An incision which is made without the use of an anæsthetic is usually inadequate and causes unnecessary torture to the patient and a break in morale which is subsequently difficult to overcome.

THE PREPARATION OF THE PATIENT

The skin of the affected area is cleansed carefully and gently first with soap and water, and then with lime and soda. Then follows immersion of the hand in an antiseptic solution such as potassium mercuric iodide, 1:3000. Tincture of iodine applied directly is likely to obscure the field, burn the skin, and cause unnecessary death of epithelium. Strict asepsis must be enforced. A general anæsthetic, such as gas and oxygen, or ethyl chloride, is to be preferred. If this is contra-indicated, block anæsthesia—catching the digital nerves at the base of the finger—should be used. The finger is elevated for about a minute and a rubber band tourniquet applied at its base. A clamp should always be attached to the tourniquet to insure its removal. The bloodless field produced by the tourniquet is es-

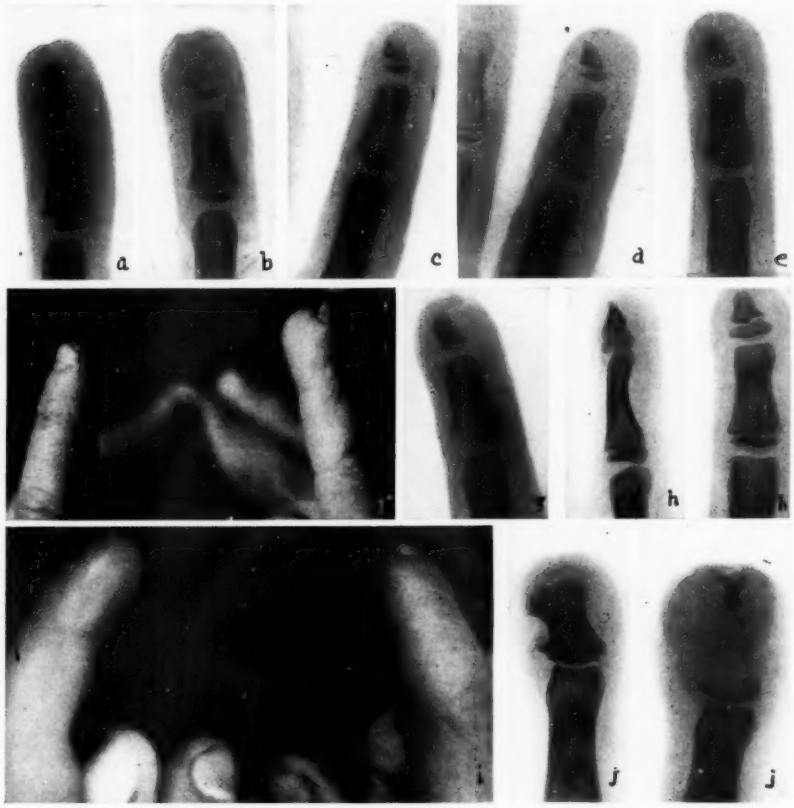

Fig. 6. a, Sequestration at epiphysis in 7 year old boy. b, Appearance of same finger as in Figure 6a, 7 days after sequestrotomy. c, 28 days after sequestrotomy. Note the increase in bone production. d, Fifty-one days after sequestrotomy. e, Seventy-nine days after sequestrotomy. f, External appearance of finger in Figure 6e at this time. Note clubbing and incurvation of the nail. g, Appearance of finger shown in Figure 6a, 93 days after sequestrotomy. h, Four and one-half years after sequestrotomy. Note the unusual intact epiphysis. i, External appearance of finger in Figure 6h. There is little change from condition shown in Figure 6f. j, A sequestrum which was absorbed and the result after 6 months. Note the distortion of the phalanx and the absence of a rounded terminal tuft.

sential to determine the amount of pathological involvement, which is a guide for the length and depth of the incision. Ethyl chloride as a local anæsthetic is very unsatisfactory in this condition.

THE INCISION

The incision should cut across fat pads and fibrous tissue septa transversely so as to drain the entire area. It should be so placed as to avoid injury of a larger blood vessel, nerves, or tendon sheath. A vertical incision into the infected area is hardly justifiable except perhaps in the proximal portion of the closed space, where, according to Auchincloss (1) the ideal incision is more likely to injure the tendon sheath. Reference to the accompanying photograph (Fig. 4) will show a half-ellipse or horseshoe which can be divided into lateral, bilateral, and hockey stick incisions. In all of them, the entire necrotic or purulent area should be exposed. The type of incision will depend upon the extent and the site of the infection. Any incision compatible with the extent of pathology which will preclude the

TABLE II.—FORTY-FIVE CONSECUTIVE DISTAL

Case No. Age and Sex	Occupation	Type of wound and method of production	Location of original injury	What appeared first	Incubation time for pain	Time after pain started that relief was sought	Location of focus	X-ray findings
105081 24—F.	Dressmaker	Puncture—pin	Lateral	Swelling	24 hrs.	48 hrs.	Lateral	None
15095 13—F.	School	Puncture—needle	Tip	Pain	?	6 days	Distal	None
105221 20—F.	Housewife	Puncture—needle	?	Swelling	24 hrs.	5 days	Distal	None
109801 40—F.	Housework	Puncture—splinter	Distal	Pain	6 days	7 days	Distal	None
103816 46—F.	Dressmaker	Puncture—splinter	Lateral	Painful blister	?	60 hrs.	Proximal	Neg.
103664 18—F.	Maid	Cut with knife	Tip of finger	Pain and swelling	2 days	1 week	Entire	None
17719 13—F.	School	Blister—puncture	Tip	Pain and swelling	24 hrs.	24 hrs.	Entire	None
62430 19—F.	School	Puncture—splinter	Lateral	Pain	Immediate	24 hrs.	Lateral	None
15489 19—F.	Cook	Incised wound—knife	Lateral	Pain	Cut occurred 16 days before coming to hospital. Pain appeared of late	?	Lateral	X-ray taken later. Extensive destruction terminal phalanx
4740 28—M.	None	Punctured—nail	Lateral	Pain	5 days	3 days	Lateral	None
15218 60—M.	Ironworker	Burn	Distal	Pain	2 days	5 days	Distal	None
109172 19—F.	Maid	Punctured wound—tin can	Central	Pain	12 days	2 days	Central	None
110162 22—F.	Housework	Cut with knife	Lateral	Swelling	3 days	4 days	Lateral	None
110160 36—M.	Porter	Unknown	Distal	Pain	Unknown	5 days	Lateral	None
109850 45—M.	Driver	Puncture—splinter	Proximal	Pain	1 day	2 days	Proximal	None
109835 31—M.	Waiter	Cut—oyster shell	Central	Tenderness	3 days	Immediate	Central	None
110623 19—F.	Clerk	Puncture—needle	Distal	Pain	2 days	6 days	Central and distal	None
108506 29—M.	Optician	Cut—glass	Lateral	Pain	5 days	2 days	Lateral	None
114803 23—F.	Trimmer	Puncture	Lateral	Pain	6 hours	2 days	Lateral	None
11198 14—F.	School	Puncture—pin	Central	Pain	24 hours	4 days	Central and distal	None
111401 52—F.	Cook	Puncture—splinter	Distal	Pain	7 weeks	3 days	Central	None
115676 44—M.	Laborer	Puncture—splinter	Proximal	Swelling	Immediate	4 days	Proximal	None
109197 50—M.	Stonemason	Continual contusion	Proximal	Pain	Unknown	6 days	Proximal	None

ANTERIOR CLOSED SPACE INFECTIONS

Anæsthesia	Type of incision	Culture	Pathological findings	Type of drainage and length	Time disability Days	End-result
Novocain	Lateral	Staphylococcus aureus	Few drops of pus	Rubber dam—48 hours	2	
Novocain	Hockey stick	Staphylococcus aureus	15 drops of pus. Slough	Ribbon Chlumsky—48 hours	15	
Nitrous oxide gas and oxygen	Pustule removed—horseshoe	Staphylococcus aureus—hæmolyticus	Free pus and slough	Chlumsky ribbon—48 hours	15	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus	2 c.cm. pus	Rubber dam through and through—2 days	24	
Ethyl chloride—general	Lateral	Staphylococcus aureus	? Pus on next and following days	Ribbon—48 hours (Replaced later)	48	
Novocain	Horseshoe	Staphylococcus aureus—hæmolyticus	Thick gray-green pus—slough	Ribbon Chlumsky—72 hours	14	
Nitrous oxide gas and oxygen	Horseshoe	Staphylococcus aureus—hæmolyticus	Much thick green pus. Flexor profundus exposed and partly digested by infectious process	Chlumsky ribbon—72 hours	18	
Novocain	Lateral	B. proteus (Contaminant)	Couple of drops of gray pus	Silk packing Chlumsky—48 hours	13	
Novocain	Horseshoe	Staphlococcus albus	Considerable brownish purulent matter. Sinus led to bone. Not roughened	Through and through gauze packing—72 hours	17	
Ethyl chloride—general	Hockey stick	Staphylococcus aureus	10 drops of pus—necrosis size of split pea	None	12	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	5 c.cm. pus	.....	35	
Novocain	Lateral	Staphylococcus aureus—hæmolyticus	Pus	Gauze iodoform	14	Scar flat.
Nitrous oxide gas and oxygen	Lateral	Staphylococcus aureus—hæmolyticus	Small amount of pus	Chlumsky ribbon—2 days	16	
Nitrous oxide gas and oxygen	Lateral	Staphylococcus aureus—hæmolyticus	Cavity—small amount of pus	Chlumsky ribbon—2 days	14	
Ethyl chloride—general	Lateral	Staphylococcus aureus—hæmolyticus	Few drops of pus	Rubber dam—2 days	8	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	Slough—small amount of pus	2 days	17	
Novocain	Long, incision volar surface by outside doctor	?	Pus	Ribbon—1 day	23	
Nitrous oxide gas and oxygen	Lateral	Staphylococcus aureus—hæmolyticus	Considerable pus—greenish slough communicating to deep pocket	Chlumsky ribbon—2 days	13	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	Moderate amount of pus	Through and through rubber dam—2 days. Replaced 3 days later for 2 days	21	
Nitrous oxide gas and oxygen	Hockey stick	Staphylococcus aureus—hæmolyticus	5 c.cm. thick white pus	Rubber dam—1 day. Ribbon—1 day	20	1 mo. End of nail cracks in cold weather. Induration at end of finger.
Nitrous oxide gas and oxygen	Bilateral	No growth	1 c.cm. thick pus	Rubber dam—2 days	15	2 yrs. Scar not seen. Pain at end of finger in cold weather 1 yr. ago.
Nitrous oxide gas and oxygen	Central	Staphylococcus aureus—hæmolyticus	Pus and slough	Ribbon—5 days	24	1 month. Letter follow-up, no trouble.
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	Pus and necrotic material 10 c.cm.	Through and through rubber dam—1 day	23	

TABLE II.—FORTY-FIVE CONSECUTIVE DISTAL

Case No. Age and Sex	Occupation	Type of wound and method of production	Location of original injury	What appeared first	Incubation time for pain	Time after pain started that relief was sought	Location of focus	X-ray findings
109075 18—F.	Waitress	Unknown	No history	Pain	.....	5 days	General—Entire space involved	5 days after pain started no evidence of bone involvement 24 days later extensive destruction of phalanx. Sequestrectomy 1 mo. after operation. Complete repair phalanx in 6 mos.
109947 26—M.	Toy maker	Puncture—splinter	Central	Blister	2 days	5 days	Central	None
109255 25—M.	Window-cleaner	Puncture	Lateral	Pain	2 days	10 days	Lateral	Osteomyelitis tip of finger
109657 44—F.	Housework	Abrasion	Distal	Pain	3 days	4 days	Distal	Extensive osteomyelitis 3 wks. after inception
116164 25—M.	Porter	Unknown	Unknown	Pain	Unknown	3 days	Lateral and distal	None
117029 52—M.	Tailor	Burn	Central	Swelling	6 days	2 days	Central	None
117154 40—M.	Carpenter	Puncture—splinter	Lateral and central	Pain	6 hours	5 days	Lateral and central	None
117125 35—F.	Housewife	Incised wound with opposite finger nail	Lateral	Pain and swelling	10 days	5 days	Lateral	None
117476 40—F.	Housewife	Puncture	Central	Pain	Indefinite	1 week	Central	None
117423 24—M.	Laborer	Contusion	Central	Pain	24 hours	4 days	Central	None
117822 35—M.	Ice-man	Burn	Proximal	Pain	1 day	6 days	Proximal and lateral	None
4470 43—F.	Housewife	Puncture	Central	Pain	2 days	2 days	Central	None
90377 29—M.	Tile-handler	Unknown	Lateral	Swelling	Unknown	1 week	Central	None
87334 11—M.	School	Abrasion	Distal	Swelling	24 hours	24 hours	Combination	None
118496 7—M.	School	Unknown	Distal	Pain	Unknown	1 week	Distal and lateral	None
119015 23—F.	Housework	Unknown	Distal	Pain and swelling	?	5 days	Distal	None
9239 44—M.	Driver	Abrasion	Central	Pain	3 days	4 days	Central	None
115802 24—M.	Clerk	Unknown	Central	Pain	3 days	4 days	Central	None
112640 26—M.	Salesman	?	?	Pain	?	3 days	Distal	None
121777 31—M.	Cigar maker	?	?	Pain	?	5 days	Central	None
120600 26—F.	Cook	?	Central	Pain	?	1 day	Distal	None
120014 49—F.	Housewife	Puncture	Distal	Pain	1 week	1 week	Distal	Suggestive of osteomyelitis

ANTERIOR CLOSED SPACE INFECTIONS—*Continued*

Anæsthesia	Type of incision	Culture	Pathological findings	Type of drainage and length	Time disability Days	End-result
Ethyl chloride—general	Horseshoe	Staphylococcus aureus—hæmolyticus	Sinus 1 c.cm. thick grayish yellow pus—fat necrosis. Involvement of subungual space	Gauze—3 days	90	
Ethyl chloride—general	Hockey stick	Staphylococcus albus	1 c.cm. thick yellow slough and pus. Sinus extends to exterior	Ribbon—9 days	21	
Ethyl chloride—general	Spontaneous	Streptococcus—hæmolyticus	Dead skin, large pus pocket. Slough adherent to phalanx. Bone roughened	Gauze—48 hours	15	
Nitrous oxide gas and oxygen	Bilateral ventral incision. Elsewhere 11 days previously	Staphylococcus aureus—hæmolyticus	Pus. Necrosis spread to middle closed space	Rubber dam—48 hours	150	
Novocain block	Horseshoe	Staphylococcus aureus—hæmolyticus	Pus. Sinus extending from lateral to medial aspect	Rubber dam—6 days	9	
Nitrous oxide gas and oxygen	Volar vertical	Staphylococcus aureus	No. pus. Tissues indurated	Ribbon—1 day	16	2 mo. Scar minimal. Tingling on change of weather.
Nitrous oxide gas and oxygen	Lateral	Staphylococcus aureus—hæmolyticus	10 drops thick yellow pus	Rubber dam—1 day	15	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	10 drops thick yellow pus	Rubber dam	31	1 mo. Scar not seen. Colder than other fingers. Painful in cold weather.
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	4 c.cm. pus—necrosis	Rubber dam—2 days	18	16 mos. Numbness 6 mos. after operation. Scar slightly tender.
Nitrous oxide gas and oxygen	Bilateral	No growth	2 drops pus	Rubber dam—4 days	11	
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	1 c.cm. pus. Considerable slough	Rubber tissue. Ribbon—3 days	21	
Nitrous oxide gas and oxygen	Bilateral	None taken	?	Through and through rubber and ribbon	13	
Ethyl chloride—ether	Bilateral	Staphylococcus aureus—hæmolyticus	10 drops thick yellow pus	Rubber dam through and through—2 days	3	
Ethyl chloride—general	Bilateral	Staphylococcus aureus—hæmolyticus	1 c.cm. dark greenish brown pus	Through and through ribbon	16	15 mos. Slight flattening end of finger. Scar minimal. Numb and cold in cold weather.
Ether	Hockeystick	Staphylococcus aureus—hæmolyticus	Few drops of pus. Small greenish slough stuck to phalanx	Chlumsky ribbon—2 days	23	1 mo. Scar almost invisible. Tender 3 months after healing.
Nitrous oxide gas and oxygen	Bilateral	Staphylococcus aureus—hæmolyticus	Collar-button abscess	Through and through rubber dam—2 days	14	15 mos. Numbness 3 weeks after healing. Painful in damp weather.
Ethyl chloride—general	Bilateral	Staphylococcus aureus—hæmolyticus	1 c.cm. thick yellowish pus	Through and through rubber dam—2 days	6	6 mos. Numb in cold weather. Finger gets colder more quickly than others.
Ethyl chloride—general	Bilateral	Staphylococcus aureus—hæmolyticus	1 c.cm. thick yellowish pus	Through and through rubber dam—2 days	29	
Ethyl chloride—general	Horseshoe	Staphylococcus aureus—hæmolyticus	½ c.cm. pus—moderate necrosis	Rubber through and through—2 days	19	1 mo. Scar is small. Numbness. Hypæsthesia.
Ethyl chloride—general & ether	Bilateral	Staphylococcus aureus—hæmolyticus	1 c.cm. pus	Rubber through and through—2 days	14	
Nitrous oxide gas and oxygen	Lateral along ulnar side	No growth	No pus found	No drainage	25	
Ethyl chloride—general	Horseshoe	Staphylococcus aureus—hæmolyticus	1 c.cm. pus slough, necrosis, sequestrum	Chlumsky pack—1 day. Iodoform—1 day. Ribbon—3 days	39	13 mos. Adherent and sensitive scar. Epithelial cleft incurvation of nail. Gets colder quicker than other fingers.

No complications were encountered after operation except in Case 15489, osteomyelitis; in Case 109075, paronychia and eponychia; and in Case 109657, osteomyelitis of the distal phalanx. No sequelæ followed operation except in Case 109075, epithelial cleft.

possibility of retraction of a flap or interference with sensation at the end of the finger is to be preferred. The half elliptical incision itself should be used sparingly but may be indicated for an infection which has already perforated the tip of the finger.

Free slough should be removed and if a loose sequestrum or foreign body is present it should be picked out. Klapp and Beck (4) recommend excision of the necrotic area, or, if this is not possible, its curettage. It is preferable to wait for a line of demarcation. If this is not done, tissue might be removed which has a good chance of living. The less necrosis and removal of fat pads the less will be the chance of a flattened volar surface of the finger as an end-result.

DRAINAGE

Incisions should be packed widely. Where through-and-through drainage is used, rubber dam is preferable. Removal of drains after about 48 hours is advisable. In this way subsequent painful dressings are avoided and the incision does not have a tendency to close as long as there is necrotic tissue at its bottom. In some instances an adequate incision without drainage is all that is necessary.

THE POSTOPERATIVE TREATMENT

A dry dressing tends to control bleeding. The finger is partially elevated by means of a sling. An active arterial hyperæmia is produced as soon as possible by means of hot soaks, leaving the bandage on and using either sterile saline or sterile water. The treatment is carried out every 3 to 4 hours for 15 minutes for the first 3 days. If the tissues become too macerated the number of soaks is decreased. Dead epithelium is removed as soon as possible. If adequate and proper incisions are made, a narcotic is usually not necessary. A granulating surface requires the application of ordinary surgical principles to insure epithelization.

POSTOPERATIVE COMPLICATIONS

Any of the pre-operative complications may occur postoperatively and would have to be treated accordingly. Osteomyelitis of the terminal phalanx is perhaps the most frequent. Gentle removal of the sequestrum after a complete line of demarcation has formed is the treatment. The sequestrum may be composed of cortical bone alone, or a combination of cortex and medulla. In many instances, a definite involvement of bone does not yield a sequestrum if adequate drainage is instituted. Under no circumstances should diseased bone be cut away.

POSTOPERATIVE SEQUELÆ AND END-RESULTS

The scar as a rule becomes almost invisible and movable on the underlying structures.

An epithelial cleft is due to an infolding of epithelium in the line of incision and probably occurs more frequently if drainage has been prolonged and if the horseshoe incision has been used. With loss of tissue from the closed space and with scar tissue pulling on the edges of the incision the epithelium has a tendency to invert itself. Excision of a wedge including the cleft and approximation of the raw surfaces usually suffices to correct this condition. The major part of an epithelial cleft may be almost flattened out by continuous use of the affected finger over a period of years. Clubbing of the finger is usually associated with an incurvation of the nail and is found most frequently following an osteomyelitis. It resembles very closely a hypertrophic osteoarthropathy.

Numbness may be persistent for months or years and is usually worse in cold weather. Tactile sensation may be diminished for a like period of time. Sometimes the finger is colder and bluer than the others; this is especially marked in cold weather.

With necrosis and separation of fat and connective tissue or bone, the volar surface of the finger assumes a flattened appearance. For this condition Kanavel (3) recommends a fat transplant. A "stubby" and shortened finger may result from sequestration even when there has been partial or almost complete regeneration of the phalanx. The last will depend upon the amount of periosteum and medulla from which new bone growth can take place. Periosteal regeneration alone is apt to produce a minimum amount of new phalanx, while under the most ideal conditions the terminal tuft is very rarely found to appear again.

CONCLUSIONS

1. In order to avoid confusion the condition under discussion is best called "the distal anterior closed space infection."

2. The anatomy has a distinct bearing on the pathology and treatment.

3. The infection as observed in a general hospital occurs most frequently in the second, third, and fourth decades and is about equally divided between the sexes.

4. A puncture is the most important etiological factor.

5. The hæmolytic staphylococcus aureus is the chief infecting organism.

6. Local tenderness is the most important sign.

7. Complications depend upon direct extension and lymphatic drainage.

8. The treatment is surgical and it is based upon the unique anatomy of the distal anterior closed space.

9. A general anæsthetic is preferable.

10. Diseased bone demonstrated clinically and by the X-ray does not necessarily sesquestrate, especially if adequate surgical drainage has been obtained. A line of demarcation in dead bone is the indication for sequestrotomy. Cutting away or curettage of dead bone is contra-indicated.

11. Removal of drains after about 48 hours is preferable.

12. The average period of disability is about 3 weeks.

13. In cases treated early and well the end-results are good. An epithelial cleft, clubbing and stubbing of the finger, incurvation of the nail, sensory disturbance and loss of substance may result. In cases in which the diaphysis of the distal phalanx has been removed or absorbed, a distorted phalanx usually results, with absence of a real terminal tuft.

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THE ACTION OF MERCUROCHROME UPON LOCAL INFECTIONS IN GUINEA PIGS

An Experimental Study

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THE object of this study has been to determine the relative rates of healing of focal infections in guinea pigs. Four series of animals were used: 1 set of untreated controls and 3 sets treated with mercurochrome-220, one locally, with applications of 1 or 2 per cent of the drug, another intraperitoneally, and a third intravenously with 1 injection of 5 milligrams per kilogram of body weight.

As is well known, it is difficult to infect guinea pigs locally with the common pyogenic organisms pathogenic for man. We found, however, that by adding a small amount of aleuronat in the form of a dry dough, infections could be obtained regularly with many different organisms. An incision was made about 1 centimeter in length down to the peritoneum along the midline of the shaven abdomen of the guinea pigs. By means of blunt dissection, pockets were then made, about 1 centimeter in width, on both sides of the incision. Into these pockets, small crumbs of aleuronat dough were inserted, and the whole lesion bathed with an 18-hour broth culture of the organism, by means of a tuberculin syringe, care being taken to reach the innermost borders of the pockets, but not to penetrate the peritoneum. After 48 hours of incubation, abscesses had invariably formed. These were purulent and the lesion elevated from ½ to 1 centimeter above the surrounding skin. Bacterial counts of smears of the pus from these lesions usually showed 100 or more bacteria per microscopic field, the organism inoculated predominating. However, secondary invaders were also found as no attempt was made to protect the lesions in any way. Reserving one-third or one-half of each group for untreated controls, the remainder were treated as desired. Observation consisted in gross examination of the lesions and in counting the bacteria in smears from the pus. The animals which received treatment had daily applications of 1 or 2 per cent aqueous solution of mercurochrome. Intraperitoneal injections of 5 milligrams per kilogram body weight, a 1 per cent solution being used, were made daily. The intravenous treatment was given by exposing the external jugular, which was injected with a 1 per cent solution of the drug. As a fine needle was used, ligation of the vein was not necessary. The skin incision was closed with 3 fine black silk stitches.

Eight groups of animals have been studied, excluding the 2 groups of untreated animals, used to determine the course of the infection.

Group III. The 7 animals in group 3 were inoculated as described, the culture being staphylococcus aureus. Three animals were held as controls and 4 were given daily local applications of 1 per cent mercurochrome. One control died on the fifth day, when the wound count showed over 100 bacteria per field. The lesions in the 2 other controls remained about the same and the count remained at 100 organisms per field. One of these animals became greatly emaciated and died the ninth day. The third control showed a count of 100 until after the thirteenth day, long after the wounds of the treated animals had been sterilized or healed. This third control then gradually improved and the lesion was healed on the twentieth day. The treated animals, all of which began with the same type of lesion and degree of infection as the controls, that is, with counts of 100 bacteria per field, presented an entirely different picture. For the first 2 days the counts remained the same, but in 3 of the 4 cases the lesions were much better after the first treatment and while the counts were still high. The lesions continued to improve steadily and all healed. From the third to the fifth day of treatment, there was a startling drop in the number of bacteria, a reduction of from over 100 to under 20 organisms. From this time on, the drop continued rapidly, reaching zero in from the seventh to the tenth day. In 1 of the 4 treated animals, healing was complete by the ninth day, in 2 by the twelfth, and in 1 by the thirteenth.

Group IV. Four pigs received the same inoculation as those of Group III, but on a different date. Two animals were reserved as controls and 2 were treated locally, 1 with 1 per cent, and 1 with 2 per cent mercurochrome. In this group, the wound counts paralleled those of Group III. The number of

organisms in the controls remained high, while those of the treated animals dropped from over 100 to 8 and 15 per field after 3 treatments and then fell rapidly to zero, which was reached the day after the sixth dose, healing being complete on the eleventh and twelfth days (pigs Nos. 12 and 13).

The count in the controls remained high and the lesions did not heal in No. 15 until 2 weeks after the last of the treated animals and in No. 14 although healing was complete soon after the treated animals, the count remained high much longer in the control.

GROUP V. Seven pigs were inoculated with the same organism and in the same way as Groups III and IV. One pig, No. 17, died, leaving 3 controls and 3 animals which received local treatment with 1 per cent mercurochrome. The count in No. 21 remained over 100 until the eighth day. Healing was complete by the thirteenth day. The second control, No. 22, had a count of 100 until eleventh day, when it suddenly fell off and healing was complete by fourteenth day. The third control, No. 20, had a smaller number of organisms throughout the infection, the count remaining, after an initial drop the fourth day, around 20, until the seventh day, when it again dropped, showed a secondary rise and finally was completely healed by the thirteenth. The 3 treated animals all began with counts of over 100 per field. No. 19 dropped after the second treatment, No. 18 after the first, with a secondary rise. In No. 16 the count remained high until the day after the fourth treatment, that is, the seventh day of infection, when it fell off suddenly and healing was complete the fourteenth day, the other treated animals being healed by the eleventh day. The treated animals had much larger abscesses than did the controls.

GROUP VI. This consisted of 12 animals, inoculated as before described. Four of these were held as controls, 4 were treated locally and 4 intravenously. The counts in the 4 controls remained up, that is, 100 per field. One pig, No. 34, died the twelfth day in great emaciation, another, No. 23, showed pus the twelfth day with a high count and did not heal until the sixteenth day. The third control, No. 33, showed a drop in count the sixth day and was healed by the fourteenth day. The fourth control, No. 32, with a high count until the seventh day, was also healed by the fourteenth. The 4 animals which received local treatment were swabbed with 2 per cent solutions. In only 1 case, No. 30, did the count remain high after the first treatment and in this it had dropped to zero by the sixth day. The 3 other animals so treated, No. 27, No. 28, and No. 26, showed drops in the counts after only 1 treatment, from over 100 per field to 35, 21, and 2 per field respectively, with a characteristic thinning of the pus, which became almost watery within 24 hours of the initial treatment. The counts in these animals dropped rapidly to zero and 1 animal was entirely well by the eighth day, the others showing marked improvement and final healing, in 1 case on the ninth day and in the other on the twelfth. The 4 animals given intravenous treatment in this series, all began with counts of 100. In 2 cases, Nos. 24 and 31, the count remained high until the fifth day, that is the second day after treatment, in 2 there was a drop by the day after treatment, in 1 case, No. 25, to 25, and in the other, No. 29, to 4 organisms in 10 fields.

In all of the animals treated intravenously, there was a typical change in the lesions consisting of a flattening out of the abscesses, followed by a rapid drying and quick healing, 1 being well by the seventh day and 1 by the eighth, 1 by the ninth and 1 by the twelfth, a better record than that shown by the animals of the same and other groups treated locally.

GROUP VII. Twelve pigs were inoculated, 4 being used as controls, 4 given local treatment, and 4 intravenous. The result closely paralleled those of Group VI. Although 1 of the controls, No. 41, showed a drop in the count on the seventh day and was healed by the fourteenth, and another, No. 45, began to drop the eighth day and was also healed by the fourteenth, the others continued to show very high counts. Of these 2 pigs, 1, No. 35, finally started to drop on the tenth day; however, healing was not complete until the twenty-ninth day. The fourth control, No. 39, showed 100 organisms per field through the twentieth day, long after the other animals were healed, and the lesion did not heal until the forty-second day.

Of the 4 animals in this set treated locally with daily applications of a 2 per cent aqueous solution of the drug, No. 35 and No. 42 showed a drop in the count after the first treatment, and the other 2, No. 43 and 44, after the second treatment. The counts remained very low and healing was complete in No. 42 by the eleventh day, in No. 36 and No. 43 by the twelfth day, and in No. 44 by the thirteenth day.

The best results in this set, however, were obtained with intravenous treatment, consisting of 1 intravenous injection of 5 milligrams per kilogram body weight. As in the locally treated pigs, in 2 cases, No. 37 and No. 46, the count fell off the day after treatment, the other 2, No. 38 and No. 40, dropping the next, or fifth day. Healing, however, occurred much more rapidly than in the series treated locally, No. 37 and No. 46 being healed by the eighth day, No. 38 by the ninth day, and No. 40 by the tenth day.

GROUP VIII. Twelve pigs were infected and 4 used for controls, 4 treated locally, 3 with 2 per cent solution and 1 with a 1 per cent solution, and 4 pigs were treated intraperitoneally with daily injections of 5 milligrams per kilogram body weight. The controls continued to show counts of over 100 bacteria per field until the eleventh day, when the counts in one of them, No. 52, began to drop, healing being complete in this case the twentieth day. Control pig No. 56 healed in the same time as No. 52, but its count did not begin to drop until the thirteenth day. The pigs treated locally, however, all showed a drop in count by the fifth day, 3 being healed by the ninth day and 1 by the tenth. Of the 4 pigs treated intraperitoneally, 3 showed a drop in count on the fifth day, the fourth pig, a drop by the sixth day. Healing was rapid, No. 53 being healed by eighth day, No. 49 by ninth, No. 58 by eleventh, and No. 50 by twelfth.

TABLE I.—SUMMARY OF THE EXPERIMENTS

Group No.	Pig No.	Treatment % mercurochrome dosage	Daily wound counts, bacteria per microscopic field																	
			3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	
III	9	None	100	100	100 Died																
	10	None	100	100	100	100	100	100	Died												
	11	None	100	100	100	100	100	100	100	100	100	100	100	65	20	1	5 to 20	0	0	Healed	
	5	Local 1%	100	100	100	12	12		2 to 10	0 to 20	0 to 20	Well									
	6	Local 1%	100	100	3	2 to 10	9	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well								
	7	Local 1%	100	100	100	100	17	9	0 to 20	0 to 20	0 to 20	Well									
	8	Local 1%	100	100	100	1 to 10	0 to 20	0 to 20	Well												
IV	14	None	50	50	50	50	50	50	50	20	4	0	Well								
	15	None	100	100	100	100	100	100	30	12	5 to 10	2 to 10	50	50	50	70	50	50	30	5	Healed 26th day.
	12	Local 2%	100	20	100	8	5	8 to 10	0 to 20	0 to 20	Well										
	13	Local 1%	100	100	100	15	0	3	0 to 20	0 to 20	0 to 20	Well									
V	17	Died 1st day																			
	20	None	70	40	70	20	9 to 10	12	3	2 to 10	0 to 20	0 to 20	Well								
	21	None	100	100	9	100	100	100	5	0 to 20	0 to 20	0 to 20	Well								
	22	None	100	100	100	100	100	100	75	100	100	15	0 to 20	Well							
	16	Local 1%	100	100	100	100	30	6 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well							
	18	Local 1%	100	30	0 to 20	100	18	5	0 to 20	0 to 20	Well										
	19	Local 1%	100	100	8 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well										
VI	23	None	100	100	100	100	100	100	100	40	50	10	1 to 10	0 to 20	Well						
	32	None	100	100	100	100	100	65	3	6 to 20	4 to 20	0 to 20	0 to 20	Well							
	33	None	100	100	100	10	50	6	6 to 20	1	3	2 to 20	0 to 20	Well							
	34	None	100	100	100	100	100	100	100	100		Died									
	26	Local 1%	100	2	2 to 20	0 to 20	0 to 20	Well													
	27	Local 1%	100	35	6	0 to 20	0 to 20	0 to 20	Well												
	28	Local 1%	100	21	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well									
	30	Local 1%	100	100	15	0 to 20	0 to 20	0 to 20	Well												
	24	*I.v. 5 mgm. to 1 kgm.	100	100	20	0 to 20	Well														
	25	I.v. 5 mgm. to 1 kgm.	100	25	6 to 20	0 to 20	0 to 20	Well													
	29	I.v. 5 mgm. to 1 kgm.	100	4 to 10	25	2 to 20	0 to 20	0 to 20	Well												
	31	I.v. 5 mgm. to 1 kgm.	100	100	30	6	2	5 to 10	4 to 10	0 to 20	Well										
VII	35	None	100	100	100	100	100	100	100	100	40	75	20	35	20	10	8	4	7 to 10	4 to 10	Healed 29th day.
	39	None	100	100	100	100	100	100	70	100	100	100	100	100	30	75	100	100	100	100	Healed 42nd day.
	41	None	100	100	100	100	30	6 to 20	4 to 20	0 to 20	4 to 20	0 to 20	0 to 20	Well							
	45	None	100	100	100	100	100	18	6 to 10	4	1	2 to 20	0 to 20	Well							
	36	Local 2%	100	20	3	2 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well									
	42	Local 2%	100	8	6 to 20	2 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well										
	43	Local 2%	100	100	4	7 to 10	4 to 20	2 to 20	0 to 20	0 to 20	0 to 20	Well									
	44	Local 2%	100	100	2	6 to 20	2 to 20	0 to 20	0 to 20	0 to 20	0 to 20	0 to 20	Well								
	37	*I.v. 5 mgm. to 1 kgm.	100	15	0 to 20	4 to 20	0 to 20	Well													
	38	I.v. 5 mgm. to 1 kgm.	100	100	5	2 to 20	0 to 20	0 to 20	Well												
	40	I.v. 5 mgm. to 1 kgm.	100	100	30	6	4 to 20	2 to 20	0 to 20	Well											
	46	I.v. 5 mgm. to 1 kgm.	100	45	2	4 to 20	0 to 20	Well													

*I.v. Intravenously.

Group No.	Pig No.	Treatment % mercurochrome dosage	Daily wound counts, bacteria per microscopic field																	
			3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	
VIII	48	None	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	Healed 27th day. Healed 32nd day.
	51	None	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	52	None	100	100	100	100	100	100	100	100	100	15	3	6 to 20	8 to 20	2 to 20	0 to 20	0 to 20	0 to 20	Healed	
	56	None	100	100	100	100	100	100	100	100	100	100	35	9 to 20	4 to 20	4 to 20	3 to 20	0 to 20	0 to 20	Healed	
	47	Local 2%	100	100	27	12	1	0 to 20	0 to 20	0 to 20	0 to 20	Well									
	54	Local 2%	100	100	40	5	8 to 20	0 to 20	0 to 20	Well											
	55	Local 2%	100	100	10	1 to 20	0 to 20	0 to 20	Well												
	57	Local 2%	100	100	15	6 to 20	0 to 20	0 to 20	Well												
	49	†I.p. 5 mgm. to 1 kgm.	100	100	22	4 to 20	0 to 20	Well													
IX	59	None	75+	100		100		50		10	100		100								(Controls: 1 died 5th day, 1 well 15th day, 3 well 19th day.) (Treated: 1 well 10th day, one well 11th day, 11 well 13th day, one on 17th, and one on 19th day.)
	60	None	40	100		100		100		25	4		Well								
	61	None	50	100	Died																
	62	None	9	5		7		15		55	80		12		5 to 20		0 to 20		Well		
	63	None	35	35		40		100		100	100		100		15		0 to 20		Well		
	64	*I.v. 5 mgm. to 1 kgm.	100	100		20		40		30	10		Well								
	65	I.v. 5 mgm. to 1 kgm.	80	80		35		25		8	5 to 10		10 to 20		0 to 20		Well				
	66	I.v. 5 mgm. to 1 kgm.	100	100		100		14		12	Well										
	67	I.v. 5 mgm. to 1 kgm.	100	100		100		50		50	35		40		8		0 to 20		Well		
	68	I.v. 5 mgm. to 1 kgm.	50	50		12		15		Well											

*I.v. Intravenously. †I.p. Intraperitoneally.

In view of the good results obtained by intravenous treatment, an additional group has been studied, being divided so that half of the animals were held for untreated controls and half treated with one intravenous injection of 5 milligrams per kilogram body weight of drug, given on the third day after inoculation and abscess formation. In this group, in which the lesions were very large, 1 of the controls died on the fifth day. With the other 4 controls, one was well by the thirteenth day, and 3 by the nineteenth day. Of the 5 animals treated with 1 intravenous injection, the counts in 3 had dropped within 47 hours after treatment, and in the fifth by the eighth day. Healing was complete in the treated animals in 1 case by the tenth day, in 1 by the eleventh, in 1 by the thirteenth, in 1 by the seventeenth and in 1 by the nineteenth. The resolution of the lesions was slower than in the other series treated intravenously, but the lesions were correspondingly larger.

SUMMARY

1. Guinea pigs with abscesses have been treated with mercurochrome locally, intraperitoneally, and intravenously.

2. The animals treated locally, as compared with untreated controls, showed a prompt and rapid drop in the wound counts with healing before the controls.

3. The animals treated intraperitoneally also showed a rapid drop in counts and healing more rapid than in the sets treated locally.

4. The intravenous injection of 5 milligrams per kilogram body weight also caused a prompt and rapid drop in count, in some cases quicker than in the animals treated locally.

CONCLUSION

Mercurochrome used locally and intravenously was found to be of benefit in treatment of infected wounds in guinea pigs. It was observed that healing after intravenous treatment was much better than when no treatment was employed and fully as rapid as with local treatment. Since in the animals treated locally there was obviously a much stronger concentration of drug in the lesion than could possibly reach it by intravenous injection, these experiments confirm other studies showing that intravenously the drug acts indirectly as well as directly.

EXTRA-UTERINE PREGNANCY: LITHOPÆDION[1]

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THE term lithopædion is applied to a fetus which has been retained within the maternal abdomen, and of which the tissues have become more or less completely infiltrated with calcium salts.

In the Mayo Clinic, 9 lithopædions have been observed in the 24-year period from 1903 to 1926 inclusive. Eight were observed at operation and 1 was removed at necropsy from the abdomen of a woman who had died from carcinoma of the œsophagus. During this same period, 445 operations were performed for extra-uterine pregnancy.

LITERATURE

The literature on the subject is not extensive, but it covers a period of nearly 5 centuries. In the early days the discovery within a woman's abdomen of such a hard stony mass having the form of a child excited wonder and speculation, and was even viewed, at times, with considerable awe. Bainbridge quotes an interesting account of the first case of which we have any record. He says: "Israel Spach in an extensive gynecologic work published in 1557 figures a lithopædion drawn *in situ* in the case of a woman with her belly laid open. He dedicated to this calcified fetus, which he regarded as a reversion, the following curious epigram, in allusion to the classical myth that after the flood the world was repopulated by the two survivors, Deucalion and Pyrrha, who walked over the earth and cast stones behind them, which, on striking ground, became people." The epigram read as follows: "Deucalion cast stones behind him and thus fashioned our tender race from hard marble. How comes it that nowadays, by a reversal of things, the tender body of a little babe has limbs nearer akin to stone?"

Kuechenmeister reviewed the literature from 1582 to 1880 and noted 45 cases which he believed to be authentic; to these he added 1 of his own. He studied these cases in detail and proposed a classification of lithopædions which is still generally accepted. Strauss, Bainbridge, D'Aunoy and King, and others, have reviewed the later literature (Table I), and we have been able to find records of 18 additional cases (Table II) not included by any of these authors, making a total, after deducting the duplicates, of 174 cases reported in the literature from 1582 to 1926 inclusive.

In 1881, Leopold reported some experimental work to show the fate of rabbit fetuses removed from the maternal uterus and left in the abdomen. He placed embryos 2.5, 5, and 8 centimeters in length in the abdominal cavities of adult rabbits. In some instances he used the fetus alone, and in others the entire embryo with its membranes intact. There was usually no reaction on the part of the host except in those cases in which peritonitis developed. By the second day the 2.5-centimeter fetuses had almost completely disappeared, and by the ninth or tenth week the 8-centimeter fetuses had been reduced to a few remnants of the paws, the integument, and the skeletal system. In the presence of infection, the process of destruction and absorption progressed much more rapidly. If the umbilical cord was ligated, absorption was slower.

INCIDENCE

The incidence in the Mayo Clinic series of 9 lithopædions in 445 cases of extra-uterine pregnancy (2 per cent) is a little higher than has been previously reported. Schumann quoted the incidence at from 1.5 to 1.8 per cent, but he believed these percentages to be too high. It is evident from the number of cases that have been reported that the condition is unusual, even more so now than formerly, because we have learned to recognize the presence of a retained fetus and to remove it surgically long before it is possible for a lithopædion to develop.

CLASSIFICATION

Kuechenmeister pointed out that calcification in the products of conception may not

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TABLE I.—SUMMARY OF CASES REPORTED IN THE LITERATURE

Reviewed by	Period	Cases
Kuechenmeister	1582–1880	47
Strauss	1580–1900	46
Bainbridge	1900–1912	37
Clark (no details given)	1880–1897	19
D'Aunoy and King	1912–1922	14
Krauss	1903–1922	26
Additional cases (Table II)	1900–1926	14
		203
	Duplicates	29
	Total	174

TABLE II.—ADDITIONAL CASES REPORTED IN THE LITERATURE

Reported by	Age of mother	Years carried	Age of fetus, months	Other pregnancies	
				Previous	Subsequent
Aievoli	32	4	6	3	
Auvray	65	30	9		
Banga	45	14	10	?	?
Bartlett	49	14	5	3 (miscarriages)	
Begouin	54	21	9	2	
Braquehaye	28	2	5		1
Legnani	?	4	9	2	
McCormick	73	51	9	1	
Maier	40	12	6	2	
Maxwell	55	?	?	8*	
Poulain	50	5	?	7	
Spackman	75	46	9	1	3
Spitz	67	26	5	1	
Tate	46	16	?	1	

*Not known whether subsequent or previous.

be entirely limited to the fetus, but may also involve the membranes and the placenta or may be entirely limited to the latter structures. On the basis of these variations he proposed their division into three groups:

1. Lithokelyphos (stone-sheath or egg-shell), in which the membranes alone are calcified and form a hard shell surrounding the fetus. The fetus may undergo only slight change or it may be completely skeletonized, but it is not involved in the process of calcification. Kuechenmeister believed this to be the most common type and the result of the membranes remaining intact around the fetus at the termination of pregnancy.

2. Lithokelyphopædion (stone-sheath child), in which both the membranes and the fetus are calcified. The amniotic fluid has escaped or has been absorbed at the time of or soon after the termination of pregnancy and the fetus remains partially or completely surrounded by the membranes.

3. True lithopædion (stone-child), in which the fetus is infiltrated with calcium salts and in which the calcification of the fetal membranes is negligible. This type, he believed, resulted when the fetus escaped unattached into the abdominal cavity, the membranes being either left behind or closely wrapped about the fetus.

While this classification has no clinical value, it provides a convenient method of grouping specimens. The confusion resulting from the double use of the word lithopædion in referring to the general group as well as to the third group could be avoided by substituting the word lithotecnon when referring to the third group, the true lithopædion of Kuechenmeister, in which the fetus alone is calcified.

In 115 cases reviewed in the literature, some attempt has been made to group the specimens according to this classification. In 53 cases (46 per cent) they are described as true lithopædion or lithotecnon, in 49 cases (42.6 per cent) as lithokelyphos, and in 13 cases (11.4 per cent) as lithokelyphopædion. These figures at best are inaccurate because the cases have been described by a large number of observers and frequently the selection of the classification depends on the thoroughness of the examination of the specimen or on personal opinion.

MAYO CLINIC CASES

CASE 1. A woman, aged 42 years, presented herself at the clinic with obstruction of the œsophagus from extensive carcinoma. She had 2 children, aged 5 and 9 years, respectively. Since the birth of the last child she had had what was thought to have been a miscarriage at about 3 months.

The patient died shortly after admission to the hospital. At necropsy the left ovary was found to be cystic and enlarged. In the fimbriated end of the left tube was a mass 4 by 3 by 3 centimeters, which on section produced a grating sensation. This proved to be a fetus, 6 centimeters long. Microscopically the soft tissues, including the lungs, contained scattered deposits of calcium salts. The specimen was classified as early lithotecnon or true lithopædion.

CASE 2. A woman, aged 39 years, had had 2 miscarriages, the first at about the third month soon after marriage. Following one of these, 19 years previously, there had been slight bleeding from the vagina

for a month, and during this time she had had several sinking spells and was ill for a week. She gradually recovered except for painful defæcation which persisted for 5 years. She complained chiefly of bloating and leucorrhœa, which had been present for 3 years.

The uterus was enlarged, firm, and irregular, and a hard nodular mass, moderately tender, was attached posteriorly to the cervix and extended well up into the abdomen. The possibility of fibromyoma was considered and exploration advised. At operation multiple fibromyomata in the uterus and a calcified mass adherent to the right side of the pelvis were removed. Appendectomy was also performed. The patient had an uneventful convalescence but a postoperative hernia developed which was repaired 3 years later. A cyst of the left ovary with the corresponding tube, which was chronically inflamed, was also removed at this time. Six years after the operation there had been no subsequent pregnancies. Menstruation had been normal, and general health good. There had been some leucorrhœa.

The specimen (Fig. 1) consisted of a calcified mass 5 by 3 by 3 centimeters in which several long bones, the ilium, and some cranial bones could be identified. There was no trace of the placenta, or cord, or other membranes. The specimen was classified lithotecnon, or true lithopædion.

CASE 3. The patient, aged 44, had been married 21 years, had had 5 children, 3 living, the youngest aged 9 years, and 1 miscarriage at about 2 months. She complained of heartburn and abdominal discomfort which had started during the last pregnancy. Occasionally pain in the upper quadrant had been noted within the last 6 weeks.

Examination disclosed marked uterine prolapse and extensive old lacerations of the perineum. A small mass which was firm and tender occupied the posterior fornix. At exploration, chronic cholecystitis with cholelithiasis was found and cholecystectomy was performed. An encapsulated mass, adherent to the sigmoid, adnexa, and surrounding structures, was removed from the left side of the pelvis. Appendectomy and a Kocher operation for prolapse were performed secondarily. Convalescence was uneventful. Thirteen years after the operation the patient's general health was good but she complained of severe vesical symptoms, secondary to recurrent uterine prolapse.

The specimen (Fig. 2) consisted of a firm calcified mass about 4 centimeters in diameter, composed of the fused and calcified remains of a fetus in which the cranial and some of the long bones could be identified. Nothing suggestive of the fetal membranes could be recognized. The specimen was classified as lithotecnon or true lithopædion.

CASE 4. A woman, aged 31 years, who had been married 10 years, had 1 child aged 5½ years. Four years previously she had had a "miscarriage." Since then she had felt weak and run down and had been aware of a sensation of weight in the pelvis. Menstruation ceased for 11 months following the miscarriage and then occurred regularly.

A hard, rough, tender mass posterior to the uterus was palpated. On bimanual examination, crepitation could be elicited. A diagnosis of a dermoid or a calcified pelvic tumor was made and exploration advised. An infected lithopædion, closely adherent to the right ovary, the sigmoid, and the small intestine was removed, together with a hæmatosalpinx from the left side. Appendectomy was performed secondarily. The patient died on the eighth day from intestinal obstruction and diffuse peritonitis.

The specimen (Fig. 3) was 8 centimeters in diameter and consisted of a hard shell with walls from 0.8 to 1.0 centimeter thick, representing the calcified fetal membranes. Within this shell was a completely skeletonized and partially disarticulated fetus, together with some pus and necrotic material. The bones of the skeleton were unusually hard and brittle. Microscopic examination of the wall revealed fibrous tissue infiltrated with calcium salts. The specimen was classified as infected lithokelyphos.

CASE 5. A woman, aged 25 years, had been struck on the back by her husband 19 months previously, when she was 3 months' pregnant. Soon afterward she became aware of a mass in the right lower quadrant and bleeding occurred irregularly and profusely for a time. She was sick for about 7 months, then menstruation recurred, and the abdominal mass decreased in size. Subsequently there had been occasional bilious attacks and slight tenderness in the right side of the abdomen.

A hard mass was palpated in the region of the right tube. The uterus was in good position and normal in size. At exploration a large calcareous mass, adherent to the small intestine, was removed from the right side, together with the corresponding tube and ovary, and the appendix. Convalescence was uneventful.

The mass consisted of a fetus, partially encapsulated by the remnants of the membranes, and with the placenta and cord attached (Fig. 4). The placenta was unusually firm and microscopically showed areas of hyalinization and calcification. The fetus was fairly well preserved but it was dehydrated and shrunken. Microscopic sections of the cord showed numerous patent vascular channels, many of which had thickened walls. The soft tissues of the body of the fetus were well preserved and were not calcified. The specimen was classified as early lithokelyphos.

CASE 6.[1] A woman, aged 52 years, had 1 child, aged 30 years. Sixteen years previously menstruation had ceased, the abdomen had enlarged, secretion had appeared in the breasts, and movement was noted in the abdomen. After 7 or 8 months she experienced slight pain in the left side and the abdomen gradually became nearly normal in size. Subsequently the patient regained health, and menstruation was normal until 8 months before admission when it became irregular. There had been frequency of urination during the last 6 months.

The patient had not lost weight. There was a hard nodular mass in the pelvis a little to the left

[1]Cases 6 and 7 reported previously by Kirklin and Simon.

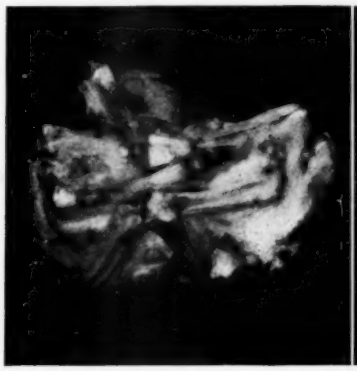

Fig. 1. Case 2. Lithotecnon retained in the abdomen 19 years.

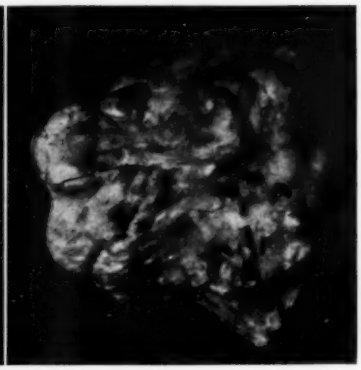

Fig. 2. Case 3. Lithotecnon removed from the left side of the pelvis.

of the uterus. Roentgenograms showed the outline of a fetal head in the left side of the pelvis, with a dense oval shadow lying across the pelvis and extending up to the level of the fifth lumbar vertebra. Cystoscopic examination revealed diffuse cystitis. A pre-operative diagnosis was made of lithopædion, and a laparotomy was performed. The greater part of the fetus was found free in the peritoneal cavity but it was partially adherent to the sigmoid and omentum. The head was contained within the folds of the broad ligament on the left side. The mass was removed and the uterus, which was adherent and retroverted, was dissected free and fixed to the anterior abdominal wall. The gall bladder contained multiple small stones and was removed 17 days later. Convalescence terminated uneventfully. Four years after the operation the patient was enjoying excellent health and was working hard.

The specimen (Fig. 5) consisted of a partially skeletonized fetus with the cord and remnants of the placenta attached. The membranes partially surrounded the fetus and were closely attached to it at several points. Microscopically they showed hyalinization and calcification. The soft tissues of the fetus were shrunken, absent in places, and there was gross and miscroscopic evidence of calcification. The specimen was classified as lithokelyphopædion.

Case 7. A woman, aged 26 years, had 1 child, aged 11 years. She had not had miscarriages. About 2 years before the examination, menstruation had ceased, and pain in the back and several fainting spells occurred. The abdomen increased in size but she was not aware of any movements as with the former pregnancy. At term she experienced labor pains and passed small pieces of tissue but no fetus. Subsequently the abdomen gradually decreased in size and menstruation reappeared, but backache persisted.

A movable mass was palpated in the lower part of the abdomen. It appeared to be attached to the uterus. Roentgenograms revealed the outline of a large fetal head and a long dense shadow lying transversely in the pelvis. Old extra-uterine pregnancy and rupture were diagnosed. The fetus was removed at laparotomy. Convalescence was uneventful.

The specimen consisted of a degenerating fetus of about 8 months' development, with the cord and placenta attached. The latter was firm and on section produced a grating sensation. Microscopically there was extensive hyalinization, and the tissues were infiltrated with calcium salts. The membranes were thickened and somewhat cartilagenous. They partially surrounded the fetus and were closely attached to it at several points. On microscopic examination, the structures appeared to be fairly well preserved, there were deposits of calcium salts throughout, especially marked within the vascular channels. The soft tissues of the fetus were firm and did not show gross or microscopic evidence of calcification. The specimen was classified as lithokelyphos.

Case 8. A woman, aged 24 years, had missed 8 successive menstrual periods 4 years previously. She had been confined to bed during practically all of the first 4 months but her health improved and she was able to do housework during the latter 4 months. With the subsequent return of menstruation she gradually regained her health except for moderate dull pain and some soreness in the right lower quadrant. Five months before examination she again thought she was pregnant. There was severe pain in the lower part of the abdomen and she was confined to bed on several occasions. Subsequently menstruation reappeared, health was regained, and all evidences of pregnancy gradually disappeared.

The cervix was small and the fundus of the uterus was moderately enlarged and retroverted. A mass, about 10 centimeters in diameter, was palpated in the left side of the pelvis, and another, about 3 or 4 centimeters in diameter, was palpated in the right

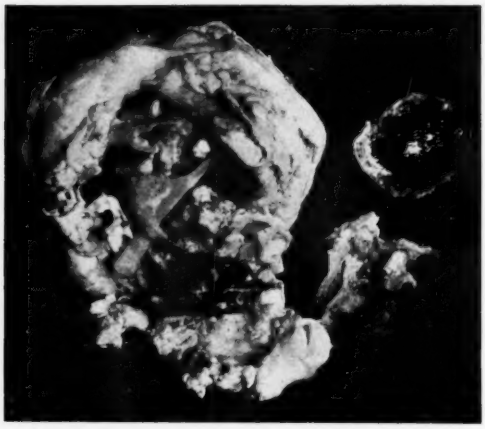

Fig. 3. Case 4. Infected lithokelyphos retained in the abdomen 4 years.

side. Operation revealed bilateral extra-uterine pregnancy. On the left side was a fetus 20 centimeters long and on the right side a lithopædion. Both fetuses were removed, together with the ovaries, the left tube and the appendix, and a plastic operation was performed on the right tube. The patient convalesced uneventfully, and a year later was well and doing all of her housework.

The specimen from the left side was a well-preserved fetus, that from the right side was a mass 15 by 9 by 6 centimeters (Fig. 6). The latter was closely adherent to an enlarged cystic ovary. The outer portion of the mass consisted of the membranes, greatly thickened and in places almost cartilagenous. When sectioned they produced a grating sensation and microscopically they showed heavy deposits of calcium. Within this shell were the remains of an almost completely skeletonized fetus, the bones were unusually hard and brittle and the soft tissues were moderately infiltrated with calcium salts. The specimen was classified as a lithokelyphopædion.

CASE 9. A woman, aged 45 years, had one child aged 23 years. She had had one miscarriage 14 years previously. Two years previously menstruation had ceased for 3 months, followed by slight daily bleeding for 1 month. Since then menstruation had occurred irregularly.

A firm mass was palpated to the right of the uterus. At exploration a fibromyoma of the uterus and a lithopædion from the right side of the pelvis were removed. Extensive inflammation surrounded the mass in the pelvis. The specimen was lost and not classified.

The classification of these 9 cases is as follows: lithokelyphos, 3 cases (37.5 per cent); lithokelyphopædion, 2 cases (25 per cent); lithotecnon, 3 cases (37.5 per cent), and unclassified, 1 case.

TABLE III.—SUMMARY OF DATA IN MAYO CLINIC CASES

Age of mother at time of operation	Age of mother at time of responsible pregnancy	Probable duration of pregnancy	Years carried	Previous pregnancies	Subsequent course
42	38	3 months	4	2	Specimen found at necropsy
39	20	?	19	1	Good health 6 years later
44	?	?	?	5 or 6	Good health 13 years later
31	27	11 months	4	1	Died
25	23	7 months	2	?	No data
52	36	8 months	16	1	Good health 4 years later
26	24	Term	2	1	No data
24	20	9 months	4		Good health 1 year later
45	43	?	2	2	No data
Av. 36.5	29	7.8 months	6.6		

The incidence of the different types in this series (Table III) corresponds roughly with that in the cases noted in the literature.

ETIOLOGY

The retention of a fetus within the abdomen, its development to the third month or more, the absence of infection, and the survival of the mother for a period of years are essentials for the production of a lithopædion. Lithopædion is invariably the result of extra-uterine pregnancy. It is extremely doubtful if a fetus retained within a normal uterus ever undergoes this transformation because there the occurrence of infection leads rather to destruction of the tissues of the fetus and skeletonization. It is conceivable that a fetus retained within the rudimentary horn of an incompletely developed uterus might escape this fate and eventually undergo calcification because under these circumstances it would be protected to some extent from infection. But even so skeletonization usually occurs.

An analysis of the pregnancies responsible for the production of the fetuses of lithopædions shows that in 84 per cent of the Mayo Clinic cases and in 73 per cent of the cases reviewed, there is clinical evidence of development to or beyond the seventh month, and in 60 per cent to term. The average term of development in the series, as nearly as could

be determined, was about 7 months. It appears that only the more mature fetuses undergo this transformation.

Leopold has shown experimentally that an immature fetus free in the abdomen of a rabbit will rapidly undergo absorption. A similar fate awaits the immature fetus which enters the abdomen of a woman on the termination of extra-uterine pregnancy.

It is impossible to obtain reliable data regarding the types of extra-uterine pregnancy that are most likely to result in the production of lithopædion. In general, it is the type in which the fetus is most likely to develop to near term and, while this may occur in practically every type, it is more common in some than in others.

In tubal pregnancy, advanced development of the fetus within the tube has been observed but rarely. Pregnancy is usually terminated before the third month except in the rare instances in which secondary tubo-ovarian, tubo-abdominal, intraligamentary, or abdominal implantation saves the fetus and permits it to develop to term. The same is true in the interstitial type of pregnancy. Primary abdominal and ovarian pregnancies are relatively rare but they reach advanced development oftener than do tubal pregnancies. Besides extra-uterine pregnancy, it is conceivable that a mature fetus might enter the abdomen as the result of rupture of a pregnant uterus and the mother recover without surgical interference. This accident, however, is usually fatal unless surgical measures are promptly instituted, and then the fetus is removed from the abdomen.

The fetus that continues to develop to maturity will die from deficient nutrition unless delivered by abdominal section. If it remains in the abdomen it will be disposed of in some manner by the maternal organism.

Mummification, adipocere and various types of fatty change have been described in these retained mature fetuses, but it is not known if these changes are entirely different processes or merely successive steps in the production of lithopædion.

The exact chemical process by which calcium is deposited in the tissues here or elsewhere in the body is not well understood.

Fig. 4. Case 5. Early lithokelyphos retained in the abdomen 19 months.

MacCallum states that there seems to be something peculiar about tissues, living or dead, which gives them the power to catch up the calcium from the circulating fluid and hold it firmly in solid form. However, no precise and satisfactory chemical explanation has been offered.

The diagnosis of lithopædion can practically always be made from the history but its presence is frequently not recognized because the condition is not borne in mind and the various events in the history are not correlated until the diagnosis has been made at operation. The symptoms may be divided chronologically into four groups corresponding to the successive stages in the development:

1. *The onset of the pregnancy.* In practically every instance the patient gives a history of pregnancy which has been atypical in some respects, depending on the type of pregnancy responsible for the production of the fetus. The symptoms may be those of ruptured tubal gestation which continues as a second-

Fig. 5. Case 6. Lithokelyphopædion which had been retained within the abdominal cavity for a period of 16 years.

ary abdominal pregnancy. In such a case the symptoms attendant on the rupture subside but the abdomen continues to enlarge and the other evidences of pregnancy persist. In other cases the symptoms may be mistaken for those of miscarriage but inquiry discloses the fact that a fetus was not passed, and that instead of the usual sequence of events following miscarriage, the abdomen continued to enlarge and the other evidences of pregnancy persisted.

In the event of primary abdominal or ovarian gestation, the patient considers herself pregnant and may notice nothing abnormal during the early months except possibly pain or unusually active fetal movements.

2. *The termination of the pregnancy.* The latter months of the pregnancy are usually uneventful, and, at or near term, labor is initiated in an apparently normal manner. The pains continue to be mild, however, and after from 24 to 48 hours they cease entirely without the delivery of a child. This constitutes what is commonly referred to as "false" or "missed" labor. The patient is no longer aware of fetal movements. She gradually recovers her health, menstruation returns, and the abdomen decreases in size.

3. *Latent period.* The fetus now ceases to exist as such. It becomes a parasite in the maternal abdomen and while it may continue to derive some blood supply from the mother, it leads only a passive existence. Its bulk has decreased with the escape or absorption of the amniotic fluid. Dehydration occurs and the tissues begin to be infiltrated by calcium salts. During this period the patient is free from symptoms except that she may still be aware of the presence of a mass in the pelvis. From 2 to 50 or more years may elapse in this manner while the fetus is being gradually transformed into a lithopædion.

4. *Late symptoms.* In about 65 per cent of cases, if the patient lives, late symptoms eventually develop. They consist of mild abdominal pain or a consciousness of fullness in the pelvis, frequently associated with a persistent, foul, vaginal discharge. Symptoms of bladder irritation may result from pressure of the mass on the bladder or from secondary cystitis. If the patient is untreated, the lithopædion may rupture into the adjacent viscera or through the abdominal wall.

The general health of the patient may be unimpaired at this time or there may be considerable emaciation and loss of weight. A hard mass, usually associated with slight tenderness, is present in the lower part of the abdomen in practically every case. On vaginal examination this mass may be palpated on one or the other side of the pelvis. It is frequently attached to the uterus, pushing it to one side. Its extreme hardness is characteristic and a crackling sensation sometimes may be elicited by pressure.

Roentgenograms are characteristic. Kirklin and Simon have pointed out that the fetus

appears much more distinctly than in a normal pregnancy because of its increased density and because it is not surrounded by amniotic fluid or the thick uterine walls. The fetus may also occupy an abnormal position and may assume an abnormal attitude, or be completely disarticulated. Other tissues besides the skeleton, which have become infiltrated with calcium salts, will produce an extraskeletal shadow of varying density and outline, depending on the extent of the calcification and the portions of the products of conception involved. Such observations in a patient who presents none of the symptoms of pregnancy, or who has passed through the menopause, or in whom a normal uterus can be outlined, are sufficient evidence on which to base the diagnosis of lithopædion.

The conditions with which lithopædions are most frequently confused are calcified fibromyomata and ovarian dermoids. In the presence of a hard mass in the pelvis, even when the history of a miscarriage or a somewhat atypical pregnancy is given, either of these diagnoses may easily pass unquestioned unless the possibility of lithopædion is borne in mind. It should be remembered, however, that fibromyomata, when they become sufficiently calcified to be confused with a lithopædion, rarely produce symptoms, and diagnosis should be made with caution when symptoms are present.

Ovarian dermoids may be a source of confusion except when they are bilateral. Previous miscarriage or atypical pregnancy is not an essential part of the history of ovarian dermoid although Koucky found that in 63 per cent of the cases in his series there was a history of previous pregnancy or miscarriage. Roentgenograms of the pelvis always furnish positive data which establish the presence or absence of lithopædion or calcified fibromyoma, and the presence of teeth will establish the diagnosis of dermoid.

TREATMENT

It appears from Kuechenmeister's article that the first case to be successfully treated by abdominal section was that reported by the barber surgeon, von Weinhardt, in 1802. Since then the relative frequency of the surgically treated cases has steadily increased.

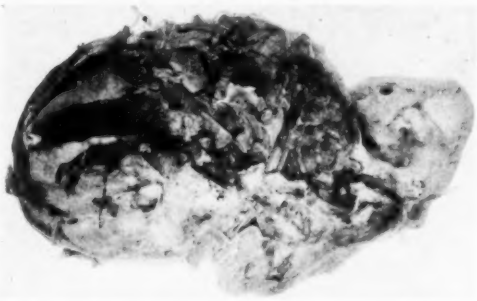

Fig. 6. Case 8. Lithokelyphopædion retained in the abdomen 4 years.

The treatment is now practically always considered to be surgical unless the patient is advanced in years and free from symptoms, or unless operation is contra-indicated for some other reason. When the calcareous mass is more or less free in the abdominal cavity, its removal is simple, but when bound down to the neighboring organs by a dense mass of adhesions, or if it has ruptured into some viscus and the whole mass is infected, its removal immediately becomes more difficult and attended by some hazard. In some instances, the uterus and adnexa are so closely adherent to the mass that it is necessary to remove them also. When the bladder or the intestines are closely adherent to the mass, it frequently happens that partial perforation has already occurred and great care must be exercised in dissecting these organs free to guard against completion of the perforation, or, when this is unavoidable, to recognize and repair it. The raw surface which remains is frequently extensive and may be the cause of the formation of adhesions and intestinal obstruction.

PROGNOSIS

A lithopædion may not cause symptoms, and its presence may be unsuspected until it is found at necropsy after the patient's death from some other cause. In more than 60 per cent of cases, however, symptoms attributable to the presence of the lithopædion develop after a period of quiescence of from 2 to 50 years. The symptoms are usually mild at first and may become more severe and be attended by marked weakness and emacia-

tion. In neglected cases, perforation into neighboring viscera or through the abdominal wall may occur.

In Auvray's case, carcinoma developed about the lithopædion, the only case on record. In the case reported by Bryant death was from intestinal obstruction.

The mortality rate from the surgical removal of lithopædion is low. In this series there was only one death; the patient had an infected lithokelyphos. The subsequent health of the patients was uniformly good over periods of 1 to 13 years after operation.

The presence of a lithopædion in itself is not markedly inimical to conception or childbearing and may exert no influence on labor. A number of cases have been reported in which conception and normal delivery have occurred in the presence of a lithopædion.

SUMMARY

Lithopædion literally means a stone child, but the name is applied to any fetus in which the soft tissues or the fetal membranes have become infiltrated with calcium salts. One hundred and seventy-four cases have been noted in the literature and 9 additional cases reported from the Mayo Clinic.

Lithopædions may be divided into three groups, depending on the structures involved in the process of calcification: (1) lithokelphos, membranes alone calcified; (2) lithokelyphopædion, both membranes and fetus calcified; and (3) lithotecnon (true lithopædion of Kuechenmeister), the fetus alone is calcified and the membranes are absent or closely wrapped about the fetus.

The symptoms of lithopædion are always typical but the diagnosis is usually not made prior to operation or necropsy because the condition is not borne in mind and the significant events in the history are not properly correlated until after the diagnosis has been established at operation. In the presence of a pelvic tumor which is unusually hard, especially when attended by symptoms, the possibility of a lithopædion should be considered. Roentgenograms constitute a valuable aid to the diagnosis. The treatment is usually surgical. The mortality rate is low and the prognosis is good following removal.

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CENTRAL DISLOCATION FRACTURES OF THE ACETABULUM

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SINCE 1778, when Henricus Allison (2) first reported a case of fracture of the acetabulum, there have come to the authors' attention fewer than 50 authentic cases of penetrating fracture of the acetabulum with central dislocation of the head of the femur. The condition has been described by different writers under various and cumbersome titles. Many of the cases were diagnosed only clinically and were unconfirmed by subsequent X-ray, operation, or autopsy findings. Vaughan has covered the subject well. Reporting a case in a comprehensive review of the literature in 1912, he was able to find only 26 positive and 39 doubtful cases. Woermer (31) in 1907 collected all reported cases—41—but rejected 25 because the diagnosis was not substantiated. Since then Kellogg Speed has reported 2 cases; Page and Bristow, 1; Cotton, 5; Ryan, 1; Coley, 1; Peet, 1; Kleinberg, 3; and Royal Whitman, 3 personal cases and mentioned 5 others that came indirectly to his attention. Fuller's series is analyzed by Vaughan. Few writers have reported more than 3 personal cases. In this article, the senior author reports 5 personal and 10 other cases from the Surgical Service of the University of Pennsylvania Hospital.

The diagnosis is made essentially by X-ray examination. A careful study of the 15 reported cases enables the authors to confirm the two types described by various authorities and to point out that the two types are but relative stages (complete and incomplete) of perforating, penetrating, or bursting fractures of the acetabulum. Fractures of the acetabulum may be divided into three groups:

1. Fracture of the rim (Figs. 1 and 2).
2. Radiating fractures of the acetabulum including fractures of the floor and epiphyseal separation of the floor of the acetabulum (Fig. 3).
3. Penetrating fractures, with or without intrapelvic displacement of the head of the femur (Figs. 4 and 5).

Cotton describes two types as smashing (radiating) and perforating (or penetrating). The difference between the two, from an etiological standpoint, is probably but a difference in the

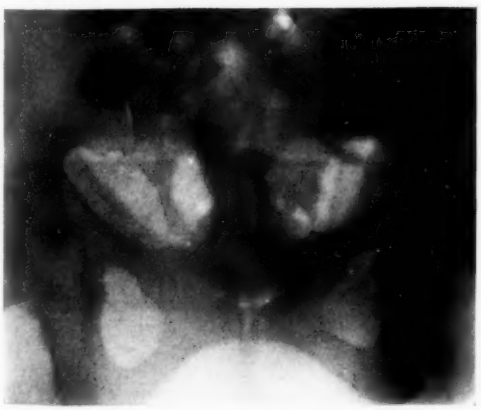

Fig. 1. Case 8. Fracture of the rim with no displacement of the head at the time of the examination. Patient fell on the trochanter.

Fig. 2. Case 14. Fractureof the rim. Note that there is the first degree of displacement of the femoral head. Direct trauma.

Fig. 3. Case 9. Radiating fractures of the acetabulum. Note the head of the femur is in the proper relation with the upper portion only of the joint surface of the ilium.

Fig. 4. Case 10. Penetrating (bursting) fracture of the acetabulum. Note the fragments driven into the pelvic cavity ahead of the femoral head.

amount of violence. In one case (Fig. 2), a certain amount of violence caused a smashing of the floor of the acetabulum in an adult, or an epiphyseal separation in the young. In a second case (Fig. 3), a greater amount of violence caused a bursting of the radiating fractured fragments; and in a third case (Fig. 4), where the violence was still greater, the head of the femur was forced through the opening caused by the preceding fracture pathology.

In reality, then, there are three stages or degrees, namely: first degree, smashing or radiation; second degree, bursting of fragments or separation; third degree, perforation, penetration, or central dislocation of the head

Fig. 5. Case 15. Bilateral fracture of the acetabulum with first degree penetration on the left side and third degree penetration or dislocation on the right.

Fig. 6. Case 9. Final result. Note the displaced fragments of the acetabular floor, but the femoral head is *in situ*.

of the femur into the pelvic cavity. The latter stage may vary from an impaction of the femoral head into the acetabular opening to complete dislocation with the head of the femur resting upon the sacrum.

ETIOLOGY

The early literature and inaccurately reported cases since then lead to the inference that the fracture and subsequent dislocation occur from violence to the acetabulum transmitted through the long axis of the femur by the neck and head of the femur. Falls from a height upon the feet probably may cause a fracture of this type, but most cases that have been carefully studied (Moore, Whitman, Coley, Kleinberg) show that direct violence upon the great trochanter is the usual etiological factor. Virevaux claims to have produced experimentally fractures of the acetabulum by violence through the femur without adduction or abduction. Katz likens the production to the jamming of a hammer or axe handle through its own head by striking the head of the handle with great violence. Kroenlein has reported a bilateral case in which the patient had fallen and landed on his feet. Both femoral heads were found to be driven into the pelvis.

Though the diagnosis of penetrating fractures of the acetabulum and their degree is principally made by X-ray examination, various presumptive signs may warrant one in making a diagnosis before reontgenologic examination is made. Attention is called to the fact that over half of the cases present fractures of other bones of the pelvis which may complicate or obscure the diagnosis. As Cotton points out, when the acetabulum is smashed and the continued violence drives the femur against the pelvic frame after perforation of the femoral head, the pelvic arch almost necessarily must give in (Fig. 5). Ryan has recently reported 25 pelvic fractures (Fig. 6).

SIMPLE CASES

1. Flattening of the trochanter of the affected side will vary with the degree of central dislocation.

2. Shortening depends upon the extent to which the femoral head is displaced. Vaughan noted in his 26 collected cases that "outward rotation of the femur occurred in 11 cases, inward rotation in 1, flattening of the trochanter in 50 per cent, and shortening as a rule."

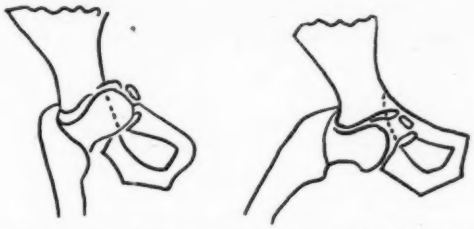

Fig. 7. Royal Whitman Abduction—Reduction. Note that the great trochanter acts as a fulcrum while the femur is abducted by drawing the head of the femur from the acetabulum.

3. Flexion, abduction, and external rotation likewise vary in amount or are absent if there is but relatively slight luxation.

4. Obturator pain depends upon fragment injury to or pressure of the femoral head upon the obturator nerve (Figs. 1 to 6).

5. Injuries to the blood vessels and bladder may occur with subsequent hæmorrhage and extravasation of urine, though these injuries are more common with accompanying fractures to the bone of the pelvis. Injury to the rectum is rare. Fuller's case (No. 2) presented blood in the fæces and urine.

6. Crepitus may be present or not, depending upon the degree of fracture and of dislocation. Sands reports a case without crepitus, external rotation, eversion of foot, or shortening.

7. Tenderness over and pain in the hip on lateral pressure over the trochanters is always present (Kleinberg).

8. Invariably there is a restriction with pain, in all movements of the thigh, though cases have walked immediately after injury (Adams) and others have been unrecognized at the time. According to Fuller, motion depends upon the size of the opening in the acetabulum. If the opening is small, motion is greatly limited; if large, the movements are free.

9. Palpation, by rectum or vagina, of the head of the dislocated femur and the displaced fragments naturally depends upon the extent of pathology in the individual case. Of 26

cases collected by Vaughan, the fracture or dislocation was felt by vagina or rectum in 14 cases.

10. Occasionally pain and tenderness above Poupart's ligament is noted (Fuller). Neuhof reports a 6½ year old girl with a full Scarpa's triangle.

11. Injury to the sciatic nerve with resultant pain and various degrees of paralysis may be noted.

12. Since 50 per cent or more of these fractures are complicated by other pelvic fractures, associated injuries may manifest themselves according to the individual case. Ecchymosis over the great trochanter, lower abdomen, and scrotum may be present with or without tenderness and rigidity of the adjacent hypogastric region. The junior author has noted in a recent case of multiple fractures of the left pelvis and ischium, a marked swelling and ecchymosis of the corresponding left half of the scrotum, occurring within 18 hours after injury due to trauma of the pudendal blood vessels of that side. Fractures of any and all bones of the pelvis may occur as complications though those of the sacrum and coccyx are extremely rare (Scudder). Injuries to the os pubis and ischium are common (33 per cent and 20 per cent of this series). Sacro-iliac affections are probably frequently overlooked while the surgeon's attention is focused upon the primary lesion. The authors cannot recommend too strongly the making of a careful and painstaking examination, in co-operation with neurologists when indicated, of all fractures of the pelvis. G. G. Davis has called especial attention to peroneal palsy (drop-foot) which he says occurs in 2 per cent of all pelvic fractures, and is due to trauma to the nerve at its origin in the lumbosacral cord, as it lies at the pelvic brim.

The nerve lesions most common to pelvic fractures are those of the peroneal, obturator, pudic, and sciatic nerves. Morrel-Lavallee reports an autopsy in which the head of the femur was found pressing on the obturator nerve, and explained the severe pain noted. Adams reports a hyperæsthesia of the lower sacral nerves disappearing in 48 hours in a case which was complicated by a sacro-iliac luxation.

NERVE COMPLICATIONS

In 15 of our cases, nerve complications occurred in 5 or 33 per cent. The sciatic was partially paralyzed in 2 cases or 13 per cent (Cases 1 and 15.) Obturator pain occurred in 3 cases or 20 per cent (Cases 6, 14, and 15). Peroneal paralysis occurred in 2 cases or 13 per cent (Cases 2 and 15). Pudic pain occurred in 1 case or 6.6 per cent (Case 2).

Injuries to the blood vessels, viscera, and bladder are most common in cases associated with multiple fractures of the pelvis. These demand immediate surgical intervention. Little appears in the literature relative to injury to the great blood vessels as these patients die quickly, the bladder not infrequently (extraperitoneally or intraperitoneally), and the urethra may be crushed or lacerated in fractures of the pubis and ischium. Acute retention of urine, hæmaturia, and extravasation of urine are to be watched for. Extravasation will depend on whether the injury to the urethra occurs anteriorly between or posterior to the layers of the triangular ligament.

In the first case the urine usually follows the rectum and reaches the margin of the anus. In the second it dissects between the two layers where it remains until suppuration occurs or the surgeon's knife intervenes. If rupture superficial to the anterior layer of the triangular ligament occurs, the urine passes into the scrotum and may mount up to the abdomen between the symphysis and pubic spine. Table I indicates the associated injuries found in the authors' cases.

It would hardly seem possible that fractures of the acetabulum with or without central dislocation could escape unnoticed or be permitted to pass without an X-ray examination. Whitman, however, observed an opera-

TABLE I.—ASSOCIATED INJURIES

	Cases	Per Cent
No other fractures	4	26
Fractures of femur	1	6
Fractures of long bones	5	33
Multiple fractures of pelvis	8	53
Concussion of brain	3	20
Fracture of skull	1	6
Alcoholism	2	13
Rupture of liver	1	6
Hæmaturia	5	33
Psychosis	1	6
Sacro-iliac separation	1	6

tion for pelvic tumor which proved to be a previously dislocated femoral head, a history and careful physical examination having apparently been dispensed with by the gynecologist. He also saw another patient who walked to the hospital with a cane, and who still had pain, 7 weeks after injury. Fuller saw a case 11 months after injury with ankylosis and atrophy of all muscles, in a young conductor 27 years old, who was practically a cripple and whose case had been diagnosed as "contusion of the hip." Kleinberg has seen 3 neglected cases and decries the making and diagnosing of roentgenograms by practicing physicians who only incidentally and occasionally use an X-ray machine of their own. One patient came 4 weeks after injury with a cane and pain, and the X-ray picture showed an acetabular fracture with little displacement of the head of the femur; the man refused treatment. A second had been kept in bed 6 weeks and then permitted to use a cane (with pain), before Kleinberg saw him. Examination revealed atrophy of the leg, and the X-ray picture showed a fracture dislocation of the acetabulum, with fracture of the os pubis. The third, a female, had been examined with the X-ray originally and the report was "negative." She was kept in bed 5 months with baking and massage, then (still with pain) was given a cane. She was seen 1 month later by Kleinberg (7 months after injury). Flexion and adduction were painful and abduction was markedly restricted. The X-ray examination showed a fracture dislocation of the acetabulum with a large intrapelvic, bulging, calcareous mass. Cotton has likewise seen a case of 33 years' duration though the man is quite active despite a stiff hip. Three of the present series were 12 to 30 months old before seen by the attending surgeon. Careful examination of the hip, movements, and measurements of the lower extremities cannot be overemphasized in all injuries to the pelvis and lower extremities.

SEX

Central dislocation fractures of the acetabulum occur more frequently in males than in females as more men are engaged in the industrial trades. Increasing rapid transportation and automobile accidents may affect either sex. In our service the sex incidence is 80 per cent males and 20 per cent females.

AGE

These fractures occur more frequently in early middle life. The youngest of our cases was 20 years old, the oldest, 58, and the average, 38 years old.

LOCATION

Kroenlein reports a case of bilateral fracture, and one such case is included in the authors' series. The majority of cases apparently appear (11 to 3) on the left side.

INCIDENCE

Though the literature and textbooks would indicate that this condition is a relatively infrequent one, the authors find it not at all uncommon. Fifteen cases were seen at the University of Pennsylvania Hospital between 1909 and 1927 at the same time that 10,300 fractures were treated, making its occurrence assume the proportion of 1:687 fractures. During this same period, 12 other fractures and epiphyseal separations of the pelvis were observed. As 4 of the reported series have occurred during the last 18 months and all were due to automobile accidents, it is thought that more fractures of this type may be seen in the future.

PRODUCTION

Of 8 cases in the literature in which the cause was mentioned, 7 were due to direct violence over the great trochanter and 1 was doubtful. Of this reported series, 4 were due to jamming injuries to the hip in automobile accidents, 2 to direct force over the hip, 2 to crushing violence, 1 to a fall on the hip while skating, and 6 were caused by falls from a height in which it could not be ascertained what part of the patient's body hit the ground first. Direct violence over the great trochanter was certain in this group in 9 of 15 cases or 60 per cent; of the 7 of 8 cases from the literature, 97.5 per cent.

TREATMENT

Delayed or non-union has not occurred in either the authors' or reported cases. The

treatment varies in simple and complicated cases depending upon whether an acetabular fracture with central dislocation alone (46 per cent) or other fractures of the pelvis are likewise sustained (53 per cent). Grave injuries to intrapelvic blood vessels demand immediate operation and transfusion. Ruptures or lacerations of the bladder require immediate laparotomy, suture of the bladder, drainage, and a permanent catheter left in place until healing is assured. Laceration of the urethra requires perineal incision, repair of the urethra, and the leaving of a catheter in place until healing has occurred.

When due to sacro-iliac subluxation, nerve injuries should be treated by immobilizing the sacro-iliac joint; when due to pressure of fragments or a dislocated femoral head, they should be treated by reduction of the dislocation and an attempt should be made to correct or change the position of the fragments under anæsthesia, by flexion, abduction, or adduction and external rotation of the thigh under the fluoroscope. If the obturator nerve is injured by the femoral head or engulfed in scar tissue or callus formation, little can be done other than the administration of palliative treatment. The sooner nerve injuries are recognized the sooner procedures and corrections can be instituted for their alleviation; when they remain unrecognized until during or after convalescence, little can be done. In peroneal nerve lesions, the foot should be supported; massage and electricity should be applied early during fracture healing. One year later, if there has been complete division or permanent damage to the peroneal nerve in the lumbosacral cord, the peroneus longus may be transplanted into the anterior tibial tendon by the Mayer technique (Scudder).

Reduction of the dislocation is best done by closed methods. Ether anæsthesia and complete muscular relaxation should be utilized. Lateral (outward) rotation and longitudinal traction under anæsthesia may be employed as advised by Cotton and others. Royal Whitman has had very good success in using extreme abduction and lateral traction, during which procedure the great trochanter engages upon the acetabular rim or ilium and with the femoral shaft abducted as a long lever, the head of the femur is forced out of the pelvis (Fig. 7). Kleinberg successfully used this method in a case of 7 months' duration, when lateral and horizontal traction or weight suspension would have been useless. Care should be used to cause no further damage than has already been done as sacro-iliac subluxation, and fractures of the pubis and ischium may injure nerves, bladder, and urethra, if manipulated violently. If the dislocation is not reducible, open operation is apparently unwise (Scudder). In a case (Vaughan) in which closed methods failed, open operations resulted in suppuration of the hip joint.

Reduction may be maintained by the use of a plaster spica including the trunk, hips, thigh, and leg, the lower extremity being abducted and externally rotated. Page and Bristow advise 50 degrees' abduction, 20 degrees' flexion, and 10 degrees' external rotation so that the limb will be in the best functional position should partial or complete ankylosis take place. If the condition has been recognized early and treated, no ankylosis has occurred in the authors' series or in those cases reported in the literature. Partial ankylosis occurred in Kleinberg's case of 7 months' standing but he nevertheless reduced it by Whitman's abduction method. Early motion will, of course, prevent ankylosis and should be instituted in all cases. In 5 or 6 weeks (Coley), the plaster spica may be cut at the knee, the leg freed and mobilized and allowed to rest in a chair, and walking permitted with crutches and later with a cane. The entire cast should be discarded 10 weeks after application if not sooner. Whitman had a recurrence when the spica was discarded after 7 weeks and the patient was permitted to walk. The dislocation was again reduced, and immobilization for 10 weeks effected a cure. Length of immobilization in simple cases will depend upon the size of the perforation. Adams used a pelvic cast for only 10 days. Speed advises a plaster spica for approximately 4 weeks in the non-penetrating type of acetabular fracture.

Loepp, in a recurrent case, used 20 pounds' extension for 3 months without splints or plaster. Scudder recommends suspension (in a pelvic cradle) and traction. The latter

should be considered in the presence of fractures to other pelvic bones. Fuller favors abduction or adduction, traction and countertraction. Simple extension and immobilization with sandbags have likewise been used. As Cotton points out, there is no standard treatment. Each case is and should be a law unto itself. Though abduction and weight extension may be sufficient in some cases, considering the number of cases with associated fractures, the plaster spica with the leg abducted, flexed, and externally rotated is probably best.

RESULTS

In the literature the results have varied. In untreated cases in which there is not great penetration, a new socket (with use of the joint) may form and give satisfactory function (Speed). There is generally some limitation of motion, slight shortening, and stiffness of the hip (Scudder, Vaughan). Lendrick once saw a middle-aged man, untreated, who later was able to take long tramping trips in German fashion. Autopsy, after death from tuberculosis, revealed the femoral head driven into the pelvis where a new bony cavity had been formed. Both pubes and ischium had been fractured. An unrecognized case in a young man seen by Fuller caused incapacitation for life. Coley's patient rode a bicycle 7 months after injury.

In the authors' series, a follow-up has been obtainable in only 7 cases, 46.6 per cent. Five of this number (Cases 5, 8, 11, 12, and 13) are doing their former work; one (Case 14), lighter work; and one (Case 15) is in an asylum with psychosis (due to fractured skull). Three have a slight limp (Cases 5, 8, and 11) and 3 (Cases 12, 13 and 14) show limitation of motion and slight pain (Fig. 6).

PROGNOSIS

Recurrence. Recurrence did not take place in any of the cases here reported. Speed advises resection of the head of the femur if the acetabular opening is large and recurrence continues. Whitman had one recurrence, Loepp another, and Schloffer has shown by the X-ray a case that primarily showed only a fractured acetabulum but 5 days later, when again subjected to X-ray examination there was found to be a dislocation due to contraction of muscles. In simple cases the prognosis is good if reduction and immobilization are accomplished early. In complicated cases the outlook is grave. There is generally some limitation of motion with slight shortening and stiffness of joints depending upon the severity of the fracture and associated injuries. Vaughan's 18 cases showed 3 perfect results, 7 with limited motion, 7 with shortening, 2 with stiff joints, 1 with outward rotation and abduction, and 1 totally incapacitated.

Mortality. None of the 15 cases in this series died. Fuller reports 50 per cent mortality and Vaughan found 30 per cent mortality in 26 collected cases, and 47 per cent in 37 doubtful cases. The mortality is due to visceral injuries, complications, and shock. Of 11 cases reported by Katz, 6 died in the first week. Arreger, reporting 33 collected cases of fractures of the pelvis (diagnosis of central fracture dislocation proved in only 6 cases), showed a mortality of 16 cases, mostly in the first week.

In general it may be stated that simple acetabular fractures with central dislocation give a low mortality. Cases complicated by other pelvic fractures causing intrapelvic and intra-abdominal injuries and by cranial injuries are to be regarded as grave, their outcome depending upon early recognition and appropriate treatment.

SUMMARY OF FIFTEEN CASES AND REVIEW OF THE LITERATURE

1. Penetrating fracture of the acetabulum with central dislocation of the head of the femur is a distinct entity and not a rarity. It is apparently on the increase because of the onward march of civilization.

2. There are varying degrees of this fracture dislocation.

3. Associated pelvic fractures occur in over 50 per cent of cases.

4. Pelvic and abdominal complications are ever to be borne in mind, anticipated, and treated early.

5. Nerve injuries occur as high as 33 per cent. Careful examinations and due regard to patients' complaints are to be emphasized.

TABLE II.—SUMMARY OF FIFTEEN CASES

Case No. Patient Sex Age	Left—Right Cause: Direct or Indirect Age of fract.	Hosp. Days Calendar Year	Treatment of fracture	Hospital result	Complications attending fracture	Remarks	X-ray reports
1 G. S. M—21	L—D 2½ yrs.	? 1909	Surg. hist. not found	Unknown	None	Old penetrating fracture of left acetabulum head of femur	Penetrating fracture of the acetabulum by head of femur, left, 2½ yr. ago.
2 M. P. M—31	L—D 1 yr.	10 1910	No treatment. Ankylosis	Unimproved	Toe-drop due to spinal injury (Spiller). Atrophy of left leg. W. Va. Coal mine hosp. Unrecognized	Shortening and weakening of leg. Unable to walk without crutches. Marked deformity. Ankylosis in slight flexion and external rotation. Head of femur near sacrum	Old fracture of pelvis through acetabulum with a joining up of the head of the femur through the fracture into the pelvic cavity to a level at site of sacrum.
3 F. E. M—20	R—D 15 mo.	0 1911	No treatment. Disp. case, old	Unimproved	Old Case.	Dispensary case. Old. No treatment	Fracture of pelvis through right acetabulum penetrated by head of femur.
4 J. K. M—53	L—D 3 hr.	32 1911	Treatment not recorded	Good union, crutches	Fracture of opposite horizontal ramus of pubis	X-ray in month showed union	Fracture of horizontal ramus of pubis and penetrating fracture of acetabulum.
5 J. J. S. M—28?	L—D 1 hr.	108 1912	Not stated	Not known	Fracture of ilium, ischium, and descending ramus of pubis	Fell 40 ft. to deck of battleship. Pain from pelvis to foot; atrophy of leg	Penetrating fracture of acetabulum and fracture of ilium, ischium, and descending ramus of pubis.
6 J. F. M—45	L—D 3 hr.	50 1913	Cast, body and leg. Thigh flexed and abducted	No shortening. Crutches	Fracture of head of femur. Uses left foot gingerly	Rectal examination painful, tenderness over Poupart's; Morris sign, obdurate pain	Fractured pelvis, perforating through acetabulum, plus head of femur.
7 V. C. M—48	L—D 3 hr.	87 1913	Sandbags 1 wk. Body cast to both thighs and upper legs	Stiffness. No shortening. Crutches	Colles fracture same side	Fairly good motion. ¾ in. shortening, external rotation	Penetrating fracture of acetabulum plus Colles' fracture (same side).
8 M. G. F—25?	L—D 1 day	43 1917	Bradford frame, double inclined plane with fracture box	Fairly good on crutches	Fracture descending ramus of pubis, same side	On 37th day X-ray "Lines of fracture do not show." Crutches on 41st day. Strain of sacro-iliac	Penetrating fracture of acetabulum and fracture of descending ramus of pubis.
9 T. D. M—24	L—D? 3 hr.	61 1920	Ether. Reduction. Cast with leg extended and slight abduction	Fair on crutches. Cast 47 days. Wheel chair 51st. Crutches 58th day	Fracture of ilium, same side	Blood in urine	Penetrating fracture of acetabulum and fracture of ilium.
10 J. N. M—58	L—? 3 hr.	57 1921	Ether, traction and counter traction. Cast with leg abducted	Fair	Fracture of olecranon and dislocation of radius, same side	No shortening, slight flexion and external rotation not walking on discharge	Penetrating fracture dislocation of acetabulum, fracture of olecranon and anterior dislocation of the radius.
11 H D W M—53	R—? Old	? 1924	Rest in bed—traction?	Fairly good		Fell off roof—at work—flexion to right angle	Old penetrating fracture of acetabulum.
12 L. M. F—25	R—D 1 day	50 1926	Bradford frame. Buck's extension	Excellent result 9 mo.	Multiple fracture of left pubis and ischium, fracture of right ilium and acetabulum. Compound fracture of left leg, Pott's fracture of right and fracture of nose	X-ray 30th day fragments in fairly good position. 46th day, wheel chair. Moves right leg easily. Back at her work with 20° motion	Multiple fractures of ramus of pubis, ascending ramus of ischium and compound fracture of tibia and fibula (left). Fracture crest of ilium, wing of ilium into sacro-iliac joint. Penetrating fracture of acetabulum, fracture both malleoli of tibia (right) and fracture of nose.
13 G. G. M—39	L—D 10 da.	7 1926	Thomas splint, Buck's extension 5 days. Plaster cast abdomen and leg	Immediate—good. Home in ambulance	Fracture neck and lesser trochanter of femur, ischium, and pubis, same side	X-ray on 5th day showed fragment in better position; walks, no pain, slight limitation of flexion	Penetrating fracture of acetabulum (left) and fracture at junction of descending ramus of pubis and ascending ramus of ischium, fracture of femur through the base of the neck and lesser trochanter.
14 W. S. M—50	L—D 3 hr.	62 1926	"Put flat in bed"	Very good	oncussion of brain. Delirium tremens. Fracture of humerus, same side. Obdurator pain	Chair on 57th day, walked on 59th day. Fracture of pelvis unrecognized for 17 days. Has pain and stiff hip; can't work because of pain	Penetrating fracture of acetabulum and fracture of horizontal pubic ramus; fracture of left surgical neck of humerus and greater tuberosity.
15 C. S. F—54	B—D 2 hr.	42 1927	Thomas splint and traction	Poor	Fracture middle fossa skull, fracture 3 ribs, left clavicle, compound fracture of left leg, ruptured liver? Peroneal palsy, obdurator pain	Traumatic psychosis, paralysis sciatic nerve	Penetrating fracture of right acetabulum; separation of sacro-iliac joint, fracture right wing of sacrum, fracture left acetabulum, fracture horizontal ramus, left pubis and descending ramus, fracture ascending ramus, left ischium; fracture middle fossa of 8th, 9th right ribs, of left clavicle, compound fracture of left leg.

6. Unrecognized fracture-dislocations occur too often.

7. Reduction is generally best achieved by anæsthesia, flexion, and wide abduction with slight external rotation.

8. Recurrence takes place if immobilization is not properly secured.

9. Immobilization when possible should be secured by a plaster spica to the body, hip, and lower extremity placed in abduction, slight flexion, and external rotation.

10. Mortality ranges from 0 to 50 per cent depending upon associated injuries, complications, and treatment.

11. Careful and frequent examinations, early treatment of all injuries, and observant study will effect a shorter convalescence, better anatomical result, and increased function.

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TRANSVERSE CONIOTOMY FOR THE RELIEF OF CERTAIN TYPES OF CASES OF LARYNGEAL OBSTRUCTION

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In a certain number of cases, laryngeal obstruction ends fatally either because immediate surgical attention is not available, or because of untoward results following tracheotomy. Transverse coniotomy (incision of the cricothyroid ligament) offers an effective procedure in some of these instances. Its simplicity puts it within the hands of every practitioner in time of emergency.

HISTORY

The origin of relieving respiratory obstruction by the operative establishment of an artificial opening below the point of obstruction can be traced back to ancient medicine. A representative of the renaissance, the anatomist Fabricius ab Aquapendente (1550), first devised the operation of low tracheotomy, which remained the only classical method until 1776. At that time another celebrated anatomist, Vicq d'Azyr (14), proposed before the Société Royale de Médecine a new operation based upon the division of the cricothyroid ligament (ligamentum conicum) and the insertion of a cannula for the relief of respiratory obstruction. Soon after this work was published, a controversy arose as to the practicability of Vicq d'Azyr's operation. Among those who strongly recommended its use were Furcroy, Bichat, and Desault (7). A number of surgeons successfully performed the "new laryngotomy" on human beings, but the operation was never generally accepted and soon disappeared.

Early in the nineteenth century, Boyer originated the high tracheotomy. About the same time, Desault (2) passed a curved tube along the nostril into the opening of the glottis and thus established the basis for O'Dwyer's work on the intubation of the larynx. In 1910, Otto Franck (5) urged the transverse division of the trachea. More recently Bingel (1) has ardently advocated this method and has pointed out its advantages. This operation, however, is a very old one, as it was introduced by Antillus in the second century.

A vast amount of literature has accumulated on the surgery of the larynx and trachea. However, only one author (12), as far as we know, mentions that the incision of the cricothyroid ligament alone suffices to produce a satisfactory opening and does not need to be followed by the introduction of a tracheal cannula.

ANATOMY

The outstanding anatomical landmarks in this operation are the thyroid and the cricoid cartilages, which are easily outlined on superficial palpation. Between the lower border of the thyroid and the upper border of the cricoid cartilage, there extends the cricothyroid ligament. The anterior portion of this structure has a trigonal shape, its sides being formed by the cricothyroid muscles (Fig. 4).

The sternothyroid muscles diverge upward and do not lie in front of the conic ligament. The sternohyoid muscles lie laterally to the ligament; however, the latter is covered by a fringe of fascia connecting these muscles. Anterior to the ligament, embedded in a small amount of connective tissue, there are a few venules and lymphatic vessels penetrating the membrane. A small lymph node may also be found here, the so-called prelaryngeal lymph gland. Also, a small, anastomotic, arterial branch crosses this field transversely, connecting the superior thyroid arteries which run laterally at a distance from the conic ligament. The course of this small artery is parallel and close to the lower border of the thyroid cartilage. This vessel can hardly be of any serious practical importance and it is not liable to be cut in a transverse incision of the conic ligament near the upper border of the cricoid cartilage.

In a certain number of individuals the lobus pyramidalis of the thyroid gland reaches the intercricothyroid space extending from the thyroid isthmus upward. It rarely consists

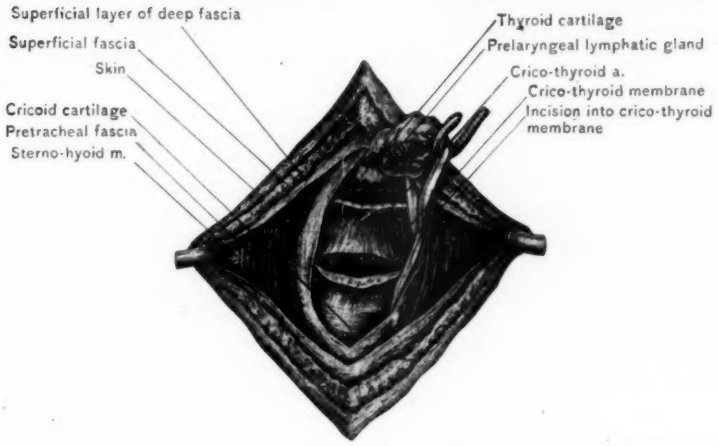

Fig. 1. Relations anteriorly of the cricothyroid membrane. (From Deaver's *Surgical Anatomy*.)

of glandular elements, but is essentially a small rudimentary structure made up of connective tissue and is of no significance whatever (12). The next layers, anteriorly, are the superficial fasciæ, and lastly a more or less insignificant amount of subcutaneous tissue and skin. In some individuals the median vein of the neck may run subcutaneously in front of the conic ligament. Figure 1 is an illustration of the topographic anatomy of the operative field according to Deaver.

Posteriorly, toward the laryngotracheal lumen, the conic ligament is covered by a thin layer of connective tissue lying directly between the ligament and the mucous membrane of the larynx. This layer connects the ligament with the mucous membrane very firmly, so that both adhere closely to each other. The entire thickness of these structures from the surface of the skin to that of the mucosa in many individuals does not exceed 8 millimeters.

With regard to the topographic relation of the conic ligament to other near-by structures of the larynx, the following has been ascertained by the examination of adult specimens.

A transverse incision of the conic ligament above the cricoid cartilage opens the upper respiratory tract at least 12 millimeters below the level of the true vocal cords. The lumen of the respiratory passage at the level of the conic ligament is fairly round and has a diameter of about 15 millimeters. It is maintained and supported by the cricoid cartilage, which is a strong, complete ring and increases considerably in size from before backward. Indeed, the posterior wall of the cricoid cartilage is about 2 centimeters high and about 3 millimeters thick. This is the only firm cartilaginous wall between the laryngotracheal tube and the œsophagus (Fig. 2).

As to the dimensions of the conic ligament itself, its height is about 10 millimeters, its length, about 15 millimeters. It does not, however, end sharply, but finds its continuation in the conus elasticus, a structure extending along the walls of the lower division of the larynx (Fig. 3).

Histologically, the conic ligament is a fairly firm, elastic membrane, whose fibers run parallel to the axis of the body, from the cricoid upward to the thyroid cartilage. Consequently, a transverse incision perpendicular to the traction force of the fibers of the membrane divides the latter into two parts, which retract spontaneously. The resultant opening has a fairly regular oval shape with a long transverse and a short vertical axis, and it remains open of its own accord. The divided mucosa, closely adhering to the ligament through dense connective tissue, follows precisely the spontaneously retracting parts of

Fig. 2.

Fig. 2. Sagittal section in the region of the cricothyroid membrane. *A*, Cricoid cartilage, anterior; *B* thyroid cartilage, posterior; *C*, thyroid cartilage; *D*, mucosa; *E*, cricothyroid membrane.

Fig. 3.

Fig. 3. Relations anteriorly of the cricothyroid membrane. (After Rauber-Kopsch.)

the ligament. These phenomena were produced on fresh cadavers at autopsy.

EXPERIMENTS ON DOGS

The anatomical differences between transverse coniotomy in human beings and in dogs are slight. The distance from the vocal cords to the conic ligament in dogs is less than in the human subject. The sternohyoid muscles in dogs lie directly in front of the conic ligament, whereas in man these muscles leave the ligament free between them.

Each animal was anæsthetized by the administration of ether and fixed on the operating table with the head in extension. Then the administration of the anæsthetic was stopped, and the dog's head, including the mouth and nostrils, was tightly bandaged with cotton, towels, and adhesive plaster. Thus breathing through mouth or nostrils was rendered impossible. A longitudinal incision was made in the midline from the incisura thyroidea down to the lower margin of the cricoid cartilage. The superficial fascia was split and retracted laterally, to expose the sternohyoid muscles which were pulled aside as shown in Figure 4. The conic ligament was incised transversely and this incision was followed by immediate spontaneous retraction of the divided parts, including the mucous membrane. In every instance, the dog at once started breathing through the artificial opening. It was possible in all cases to perform the operation rapidly enough to relieve the animal from asphyxia. No complications arose on the operating table and ligatures were not necessary. The operative procedure was carried out with only one instrument—a scalpel, and was performed without assistance.

Before the dog was removed to the cage, precautions were taken in order to maintain the coniotomy opening patent, as the materials obstructing the mouth and nostrils were left in place and respiration could be carried on only through the artificial opening. Strips of adhesive plaster were fixed to the skin on either side of the incision wound, and were united in back of the dog's neck. The sternohyoid muscles, which in dogs lie directly in front of the cricothyroid membrane, being sutured to the overlying skin, were retracted with it. In front of the operative field a small thin layer of gauze was applied by means of collodion. As suture material, silk was used.

A lapse of 24 hours was allowed between the operation and the removal of the materials obstructing the dog's mouth and nostrils. During that time the respiration remained undisturbed and the heart action was equally good. Following the removal of the obstructive materials, in one group of dogs the artificial opening was kept patent for a period of 4 days. Then the skin edges were permitted to approximate and the wound was allowed to close. In another group of dogs, the closure of the wound was facilitated immediately after the removal of the obstructive materials from the mouth and nostrils. In some cases the edges of the skin as well as those of the divided fascia were united by a few interrupted sutures. In no case, however, was the wound closed completely.

Two dogs were killed and autopsies were carried out 24 hours after operation. When the interior of the laryngotracheal passages of these animals was exposed, no blood was found in the lumen, and the mucous membrane was pink and normal in appearance. The vocal cords showed no trace of any injury. The entire mucosa showed no changes except at the cricothyroid interspace. Here an approximately oval shaped opening was seen, with clean-cut and sharply outlined edges. The mucous membrane adhered closely to the divided parts of the conic ligament (Fig. 5).

In the dogs allowed to live, the wounds became infected. However, the infection remained localized, and aside from the delayed healing of the wound, was of no appreciable significance. Soon after the closure of their wounds (8 to 15 days after operation) the dogs started barking again, and there was nothing suggestive of any laryngeal lesion. These dogs were allowed to live for a period of from 1 to 5 months and were further observed with regard to the possibility of undesirable after-effects. In no instance was there any evidence of vocal disturbance or of any impairment of breathing.

At autopsy the following was found uniformly: The skin was movable over the operative field, and the site of the longitudinal skin incision could be found only on very close examination. The larynx and trachea were removed from the body *en masse*. Externally, these organs showed no deformity. The lumen of the larynx at the cricoid level was fairly round; the entire mucosa was smooth and pink in color; and there was no loss of continuity in the lining of the mucous membrane. The cricothyroid interspace showed no appreciable changes on superficial inspection. The transverse incision through the conic ligament was not perceptible. Only on very careful examination could one make out in the submucous layer a round area about ¾ centimeter in diameter, suggesting a radiating, scar-tissue formation with its center approximately in the middle of the cricothyroid interspace. The vocal cords were found intact and covered by a lining of normal looking mucous membrane.

REPORT OF CASE

I. S., a white male, 60 years of age, complained of increasing hoarseness for 2 months. The patient had a loud inspiratory stridor and his speech was only a hoarse whisper. Laryngoscopic examination revealed a hard, immovable mass involving both the true and false cord on the left, extending upward posteriorly and along the left wall of the larynx. This mass protruded above the left aryepiglottic fold, and obstructed a very considerable part of the entrance to the larynx but was not ulcerated. The right vocal cord was movable, the left was fixed. The epiglottis was swollen and congested. There was nothing else of significance in the physical examination. The history was irrelevant except for the fact that the complaint dated back some 4 years prior to admission to the hospital.

Fig. 4. Transverse coniotomy, external view (dog).

The condition obviously was a carcinoma of the larynx. It was suggested by Dr. H. L. Swain, who knew of our work and to whom I am indebted for the privilege of reporting this case that a transverse coniotomy be performed on this patient instead of a preliminary tracheotomy.

The coniotomy was performed under local anæsthesia, with the patient's head in extension. The longitudinal incision of the skin was about 3 centimeters long, and the transverse incision of the conic ligament was about 1¼ centimeters long. The patient remained well during the operation and started breathing through the coniotomy opening immediately after the conic ligament was split. All bleeding points were carefully ligated. The skin edges were caught by two stitches (silk), and the threads were tied to strips of gauze on either side of the wound. The two strips were tied on the side of the neck so as to retract the wound edges somewhat from the opening. On inspection of the respiratory passage through the coniotomy opening, the mucosa was found to be of normal color; it was possible, without any difficulty, to inspect the lower surface of the vocal cords.

Soon after the operation, it was observed that the patient was not breathing through the coniotomy opening as satisfactorily as he had on the operating table. On inspection of the wound, a small flap of loose prelaryngeal tissue was seen attached near the coniotomy opening. This piece of loose tissue, during inspiration, was blown in toward the tracheal lumen, obstructing the opening in the conic ligament in a valve-like manner. Also the edges of the skin were not retracted from the coniotomy opening far enough to avoid its being covered by the skin, when the patient moved his head to the side.

For this reason, about 12 hours after the opera-

Fig. 5. Transverse coniotomy, internal view (dog).

tion was performed, a tracheal cannula was introduced through the coniotomy opening, and was kept in the respiratory lumen for a period of 5 days. On the sixth day, the cannula was removed. The skin around the opening in the conic ligament was adhering closely to the underlying tissues, and the opening remained free regardless of the position in which the patient chose to hold his head. For the following 12 days the patient remained perfectly comfortable without any cannula. As the stream of air passing through the opening tended to dry up the secretions from the respiratory passages in the lumen of the opening, it was frequently necessary to remove from it the dried up particles as well as the moist expectorated material. Figure 6 represents a photograph of the patent coniotomy opening on the eighteenth day after the preliminary coniotomy was performed. On the same day, a complete laryngectomy was performed by Dr. Samuel C. Harvey. During the operation, the anæsthetic was administered through a catheter introduced into the trachea through the coniotomy opening.

PROCEDURE IN MAN

In operating on man, the skin edge should be retracted on either side and fastened to the underlying tissues by mattress sutures entering the skin about 2 centimeters away from the edge and passing through the anterior cricothyroid muscle of that side, thus preventing obstruction of the coniotomy opening regardless of the position of the head and neck. Strips of adhesive plaster may replace this procedure if necessary. After a few days the sutures may be removed, and the adhesions allowed to maintain the desired position of the skin. Whatever is done after the coniotomy opening is no longer needed, the wound should not be closed tightly, and the conic ligament should not be sutured.

It is necessary to identify the cricothyroid interspace before the incision is made. The skin incision should extend from the incisura thyroidea to the lower border of the cricoid cartilage. The conic ligament should be incised exactly transversely. The loose prelaryngeal tissue must be removed as we found from experience in the reported case.

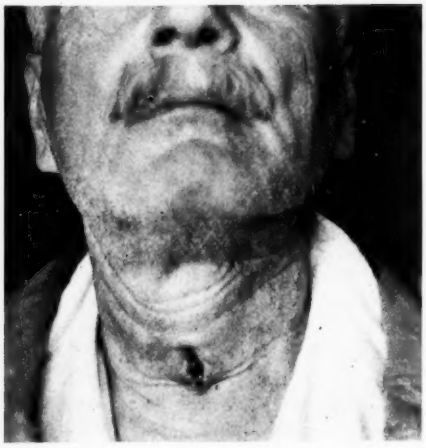

Fig. 6. Transverse coniotomy, 18 days after operation.

ADVANTAGES AND DISADVANTAGES

A simple solution for the emergencies of laryngeal obstruction by the present methods is not always possible. While O'Dwyer's intubation method is of great value chiefly in diphtheria in children, it is not advantageous in other conditions. Both intubation and tracheotomy require special instruments, and tracheotomy is a major operation which demands skill and some experience on the part of the operator. Even when performed under the best circumstances, tracheotomy may give rise to serious complications such as hæmorrhage. Following the teachings of Chevalier Jackson (8), most tracheotomies in this country are of the low type, so that the serious complication of laryngeal stenosis is eliminated. Under certain circumstances, however, stenotic changes may follow tracheotomy regardless of the anatomical level at which the operation was performed.

In contrast with these methods, the operative field in transverse coniotomy is most superficial, and the anatomical structures in-

volved are of relatively little significance; cartilaginous substance is not cut, and the lumen of the air-passage is not altered; the method reduces the possibility of hæmorrhage and other complications to a minimum; it opens up the largest of the interspaces between the laryngotracheal segments below the vocal cords; it offers to every practitioner a simple and easy means of interference in emergency; and it requires the use of only one instrument —a knife. The postoperative development, other things being equal, is most favorable.

It is interesting to note in connection with this operation that the chief arguments advanced against it for the past 150 years have always remained the same: the proximity of the operative field to the vocal cords, and the wearing of a cannula in the subglottic space. Harmer (6), arguing in favor of this operation, claims that "a tube introduced through the cricothyroid membrane lies in the subglottic space well below the vocal cords," and that healing of the wound takes place in from 5 to 20 days. St. Clair Thomson states (10): "Intercricothyrectomy is free from danger and easy to perform," and "the wound will heal in a few hours." Both Harmer and St. Clair Thomson find the method advantageous not only in sudden laryngeal obstruction, but as a preliminary temporary measure in certain other operations.

Since we feel justified in stating that, on anatomical grounds as well as on the basis of our results on living subjects, coniotomy does not require the use of a cannula at all, it is needless for us to share the fear of a cannula in the subglottic space. As to the possibility of directly injuring the vocal cords, it may be said that such an injury cannot occur, if the operation is performed with any care at all. It is necessary to realize that indications for transverse coniotomy are limited. It is obvious that only such respiratory obstructions come into consideration as are located above the level of the cricoid cartilage.

The so-called "œdema of the glottis" is the outstanding condition in which transverse coniotomy may save the patient's life. It may occur at any age, and may be associated with many conditions, such as Ludwig's angina or any other inflammatory process in the vicinity of the larynx, burns or caustic irritation to the fauces, foreign bodies in or injuries to the larynx, angioneurotic œdema, some acute and chronic infections, general anasarca. Because of its frequent abrupt onset, its rapidly progressive character, and its tendency to give rise to no distressing symptoms at the onset, these conditions often confront the practitioner when the patient is in real danger of suffocation. In connection with "œdema of the glottis," it may be pointed out that this is a misnomer; the condition manifests itself by a serous infiltration chiefly of the aryepiglottidean folds, and not of the glottis. It is an anatomically as well as clinically (11) well established fact that œdema of the larynx does not spread downward, and never involves the subglottic space. The site of this lesion is always at a higher level than the operative field of transverse coniotomy.

Foreign bodies may lodge in the additus ad laryngem and produce a rather alarming situation. For some reason or other it may be impossible, at the time, to remove the foreign body from the larynx, and the physician may be urged to establish rapidly an artificial respiratory opening.

Injuries to the larynx, particularly cuts through the hyothyroid membrane, and fractures of one or more of the cartilages, may become very serious. The resulting inflammatory reaction may cause severe œdema of the larynx, or the lumen of the larynx may be occluded by either a dislocated fragment or a hæmatoma developing in the submucous connective tissue. For this reason such patients are in constant danger. For the sake of safety, some authors emphasize the necessity of a prophylactic tracheotomy in cases of trauma of the larynx. Provided the cricoid cartilage has not been fractured, transverse coniotomy should be preferred invariably in such cases.

For the establishment of a preliminary artificial respiratory opening, transverse coniotomy approaches an ideal of safety. If it is desired to administer a general anæsthetic, this can be accomplished either through a soft rubber catheter inserted through the coniotomy opening, or else by saturating with the anæsthetic a loose piece of gauze placed in front of the opening. As an example of an indication of coniotomy as

a preliminary measure, the operation for the removal of a carcinoma at the base of the tongue may be mentioned. Furthermore, the possibility of inserting a radium needle through the coniotomy opening for direct application for subglottic tumors, may be mentioned here.

CONTRA-INDICATIONS

In *diphtheria*, coniotomy should not be practiced because the obstruction of the air passages by the membrane may extend below the cricoid level. In *children* the distance between the cricoid and thyroid cartilages is too small and promises little success. We, therefore, believe that coniotomy should not be practiced in children.

SUMMARY

1. Many instances of laryngeal obstruction in the adult can be relieved by the transverse coniotomy of Vicq d'Azyr.

2. The introduction of a cannula is not a necessary step in the procedure, because of the anatomical character of the cricothyroid membrane.

3. The procedure is simple and should be used in such emergencies as must be met without the assistance of a surgeon.

4. It is not applicable in children, because of the small size of the membrane and not in obstruction which may lie below the thyroid cartilage, as in diphtheria.

5. The operation is of particular value in the establishment of a temporary artificial airway in operations at the base of the tongue, about the pharynx, and buccal cavity.

6. This paper is based upon anatomical studies on the cadaver, experimental work on the dog, and upon the application of the procedure in one case.

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MENSTRUAL FISTULÆ OF POSTOPERATIVE AND ENDOMETRIAL ORIGIN

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"MENSTRUAL FISTULA" is proposed as a term for fistulæ in laparotomy scars characterized by periodic discharge of blood, more or less coincident with normal menstruation. Two kinds of such fistulæ have to be considered: (1) those due to direct communication with the uterine or tubal mucosa; (2) those due to postoperative enclosures of endometrial tissue in abdominal scars.

ETIOLOGY

Most menstrual fistulæ are of postoperative origin, though a few such fistulæ have been formed by a pus tube or a tubal pregnancy spontaneously breaking through the abdominal wall (cases of Bouzol, 4; Deverre, 8; Schlink 35). Postoperative menstrual fistulæ are caused:

1. By postoperative direct communication with uterine or tubal cavity: (a) following cæsarean section; (b) after operations for pelvic inflammatory disease, salpingectomy, partial hysterectomy; (c) after ventrofixation of the uterus.

2. By postoperative enclosure of endometrial (adenomyomatous) tissue in the abdominal wall, in the course of hysterectomy, ovariotomy, ventrofixation, etc.; such enclosed tissue also at times causes a periodic menstrual discharge, as we will show later on.

It is obvious that the menstrual discharge from a fistula going into the uterus is much greater than that from the type caused by endometrial enclosures; in fact, under certain mechanical conditions the whole or most of the menstrual flow may emanate through the fistula in the former type. The enclosures give only a slight but more or less periodic discharge.

Of fistulæ following cæsarean section, the following notes were found in the literature:

Olshausen (27) mentioned in his lectures that the so-called Porro operation was at times followed by menstruating fistulæ. The old Porro operation meant supracervical hysterectomy immediately after a cæsarean section with suturing of the cervical stump into the lower angle of the abdominal section. The aim of the procedure was prevention of peritonitis emanating from the uterus or, after its removal, from the infected cervical stump. As tubes and ovaries were usually not removed in the Porro operation, the broad cervical stump menstruated the natural way through the vagina. If the cervical stump was attached to the abdominal wall, an abdominal fistula often resulted, communicating with the cervical canal and, therefore, participating in menstruation.

Holland (13) mentions the possibility and gives the origin of such fistulæ after cæsarean section. Discussing defects in the classic cæsarean operation, he says: "Every one knows how, during the stage of closure of the wound, the incision tends to gape transversely and the edges are drawn apart when the uterus contracts. If the contractions are very powerful, small gaps, which become occupied by blood clot, inevitably occur between the sutures. Many cases have been described in which it has been necessary to reopen the abdomen, or which have come early into the postmortem room, and the wound has been found widely open. If infection of the uterine wound occurs, healing is delayed and an imperfect scar is formed. The liability of such thin scars to rupture in subsequent pregnancy or labor is very great. Even in case of mild infection, the position of the incision makes adhesions between the uterine scar and omentum, intestines, or abdominal wall, almost inevitable." Such adhesions, if intestines are involved, often lead to chronic or acute intestinal obstruction in the adherent intestine, or breakdown of the kinked intestine with formation of fæcal abscess and fæcal fistula. Then perforation of the thinned adherent uterine scar by erosion from the fæcal fistula may lead to menstrual fistula. We will see later that

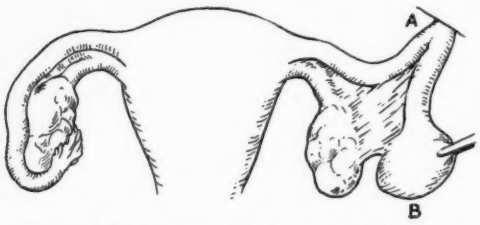

Fig. 1. Schlink's case of tubal menstrual fistula in the groin. *A*, Cutaneous fistula of the tube in the groin; *B*, obstructed fimbriated end of tube (hydrosalpinx).

several menstrual fistulæ were complicated by small fæcal fistulæ.

Loicq (20) in 1922 first wrote a compilation of cases of "uteroparietal fistula following cæsarean section," and reports a case of his own:

A woman, aged 38 years, after 6 previous pregnancies were terminated once by premature labor, twice by pubiotomy, and 3 times by forceps, was delivered of her seventh child in November, 1922, through an ordinary high cæsarean section. The uterus was closed by separate sutures of the muscular layer (silk) and of the peritoneum (catgut), the abdominal wall being sutured in 4 layers. The patient had fever for 10 days. Twenty-four hours after removal of the stitches on the eleventh day, the abdominal scar gave way completely, thus making necessary a new suture. The wound suppurated for several days and when the patient left the hospital 12 days later she still had a fistula at the lower extremity of the abdominal scar. *During the next 2 menstrual periods, blood flowed through this fistula,* and in March a sound could be passed through it and into the vagina. In April the scar was excised by an elliptic incision. The uterus was adherent to the parietal peritoneum, while the ovaries were polycystic and the tubes thickened and adherent in Douglas' fossa. The operation was terminated by incomplete hysterectomy.

Loicq (20) found reports of 28 additional cases of uteroparietal fistulæ in the literature. The principal cause of this condition is infection. The fistula may be blind or complete. The diagnosis of the latter is easily made from the flow of menstrual blood through the parietal opening and by exploration with sounds or injection of colored fluids. Such fistulæ do not necessarily prevent the normal development of subsequent pregnancies.

Loicq gives a method of prevention of such fistulæ, first, by proper suture of the uterine wall, and points out that the possibility of these fistulæ would also be greatly decreased if a low cæsarean section were always performed. Uteroparietal fistulæ may be treated by dilatation, injection of modifying substances, cauterization, or by uterine suture. When the fistula is complete, excision of the fistula and suture of the uterus may be contemplated, or hysterectomy, if it is feared that the tissues are so badly infected as to preclude the probability of thorough healing (Loicq).

Puccioni (20) reports 2 cases of uteroparietal fistula following cæsarean section. The first case was that of a 27-year-old woman. Operation had been performed for a supposed ovarian cyst, but a 5-months' pregnancy was found. For some reason a cæsarean section was done. The abdominal wound did not heal and continued discharging for a period of 2 years. The patient then came to his clinic, where the diagnosis of abdomino-uterine fistula was made. In the fistulous region there was an extensive intestinal hernia. The second case was that of a 32-year-old woman, who after 4 abortions and 2 pregnancies at term, had the last of these terminated by cæsarean section. In this case also, a fistulous tract appeared in the abdominal scar soon after the cæsarean section. This tract ordinarily drained pus, *but at the menstrual periods blood issued from it freely.* Examination 2 years after the cæsarean section showed the sigmoid colon perforated in its median portion. The perforated uterine fundus was in communication with the sigmoid and the exterior by fistulæ.

The author also states that the causes of uteroparietal fistulæ following cæsarean section must be looked for in faulty asepsis during the operation, secondary infection, and faulty operative technique. The classic cæsarean section, particularly in the upper part of the uterus, predisposes to the formation of a uteroparietal fistula. As to treatment he states: "While spontaneous recovery may be favored by the occurrence of a new pregnancy when the fistula is in the evolutionary stage, there is grave danger of uterine rupture in the second pregnancy. The best treatment consists in the removal of the abdominal scar and the fistulous tract (including the origin of this tract) by means of 'cuneihysterectomy' or subtotal hysterectomy according to the extent of the lesion. This operation must be followed

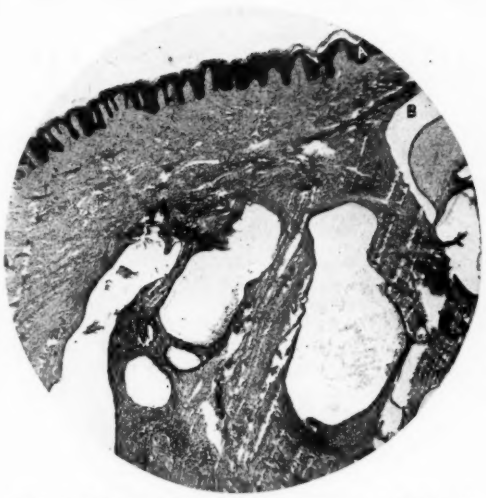

Fig. 2. Endometrial enclosure in Case 3. *A*, Epidermis of the abdominal wall; *B*, the cystic endometrial enclosure.

Fig. 3. From the same section as shown in Figure 2, high power.

by perfect reconstruction of the abdominal wall."

While the literature on menstrual fistulæ following cæsarean section embraces at least 32 cases including the 28 mentioned by Loicq, communications of spontaneously formed fistulæ from inflammatory conditions and tubal gestations are more rarely mentioned. Winkel mentions in his textbook, under the head of "vicariating (substituting) menstruation," a case of Bouzol: A progressed extra-uterine pregnancy had become attached to, and fistulous in, the abdominal wall. After discharging extra-uterine fetal parts, the fistula kept on discharging *blood at intervals* and also a slight amount of fæcal matter (menstrual with complicating intestinal fistula).

Schlink (35) describes a tubal fistula originating from a pus tube in the groin, discharging pus and at times blood:

> A small gland in the right groin was dissected out, in a woman, aged 30 years. The wound did not heal thoroughly; a small sinus discharging pus and at times blood persisted, and for months resisted all efforts at closure. The sinus was filled with bismuth paste and an X-ray showed a sinus shadow leading in the direction of the internal abdominal ring about 2 or 3 centimeters in length and a large shadow in the midline of the pelvic cavity; the paste evidently had made its way into the uterine cavity, as it was passed *per vaginam* in a very short time. Upon laparotomy a condition such as shown in the diagram was found (Fig. 1). The tubes were the seat of an old salpingitis. The fimbriated ends were sealed and filled with clear liquid. The right tube was kinked almost in hairpin fashion, and the bend was adherent to the anterior abdominal wall in the region of the abdominal ring. Double salpingectomy cured the condition.

Deverre (8) reports a menstrual fistula from a spontaneous rupture of a large "perimetro-salpingitis" through the navel.

> A woman, aged 25 years, since marriage in 1913 had suffered for 6 years from typical symptoms of pelvic inflammatory disease. In 1918, there was marked abdominal distention, intestinal disturbance, and great emaciation. Late in 1918, there appeared in the region of the umbilicus a little swelling which became progressively more marked, the skin became thinned and red and finally ulcerated and discharged pus for several days, "*then blood in greater or lesser amounts*," with intervals during which pus was discharged. A cure was established by 2 operations. First, a large bottle-shaped pus cavity was found in the right pelvic region, the upper extremity of which reached to, and communicated with, the umbilicus. The cavity was drained. Suppuration continued. At a second operation 3 months after the first, a subtotal hysterectomy was performed. In front of the old cutaneous fistula, a second pus pocket was found and the appendix was entirely detached from the cæcum. The patient recovered after a rather stormy convalescence.

Fig. 4. *X*, The area near interruption of the epidermal layer showing the proximity of the cysts to the surface and the mechanism of hæmorrhagic discharge.

The case of a pyosalpinx "fistulizing" into the bladder reported by J. Duvergey and Dax (10) suggests the possibility of menstrual blood being periodically discharged through the bladder, as may also occur in the second type, an endometrial enclosure in the bladder (Keene, 16).

A woman, aged 34 years, was admitted complaining of general exhaustion and intractable cystitis. Urotropin, infusions, and vesical lavage with nitrate of silver had been employed without effect. The urine was loaded with green pus and at times blood. Vaginal examination showed that the uterus and adnexa were immobilized in an inflammatory mass filling the pelvis. Especially a large tumor of the right tube could be palpated, which was adherent to the wall of the bladder. Catheterization of the left ureter was easy, but it was impossible to catheterize the right. Radiography, after the intravesical injection of 5 cubic centimeters of sodium bromide showed the shadow of the right tube communicating with the bladder. Following lavages of silver nitrate during a period of about 6 weeks, the fistula closed, the adnexal mass disappeared, and the cure was eventually complete. Ordinarily abdominal hysterectomy is indicated in cases of salpingovesical fistula, but the poor general condition of this patient contra-indicated surgical intervention.

Our 2 cases of direct menstrual fistula followed operations for salpingitis and ventrofixation:

Case 1. Mrs. L. E., aged 36 years, admitted to Harper Hospital October 5, 1922, stated that she had been married 6 years, but had had no children. In 1917, on account of sterility, backache, and dysmenorrhœa, she was operated upon for "falling of the womb." She was re-operated on account of pain a few months later, adhesions were separated, and one ovary was resected. Following this operation, there was much pain radiating into the legs, and a fistula in the laparotomy scar continuously discharging serous material, some intestinal gas, and small particles of thin stool. At times the discharge became stopped up and then a swelling appeared, which was painful until it broke and discharged thick reddish menstrual-like blood. The vaginal menstruation was very scanty. The patient was in excellent general condition. Diagnosis: intestinal and menstrual fistula following operation for retroflexion. She was operated upon again by us on October 7, 1922.

The fistula was packed with iodoform gauze. Through an elliptic incision surrounding the fistulous scar of the former low laparotomy, the whole scar with the fistula was dissected from the abdominal wall; the fistula, 2 millimeters in diameter, communicated with the ileum. Other diffuse intestinal adhesions were present. The intestinal fistula was closed by 2 inverting sutures and an omental graft. This fistulous tract also went to the uterine stump. Details, on account of inseparable adhesions, could not be made out. This patient was not cured by operation. When last seen, March 10, 1924, she still discharged a slight amount of gas and stool, and, at times, menstrual blood, painfully. As her general health was good, further attempt to do a radical operation, meaning perhaps intestinal resection and total hysterectomy, was not considered, especially in view of the fatal outcome of such an attempt in the next case.

Case 2. Mrs. T. B., 55 years old, first seen on May 31, 1923, stated that 10 years before she had been operated upon for a pelvic inflammatory condition. She was told after the operation that she had pelvic tuberculosis and that one tube had been removed. From this operation, a fæcal fistula remained in the scar, which constantly discharged gas and a small amount of stool. At intervals of 2 to 3 weeks, some bloody discharge would come from the fistula, with much pelvic distress. Four operations at other clinics had been performed since without perfecting a closure of the fistula. The constant fæcal and gas discharge, frequent painful bloating, especially at the time of the bloody (menstrual) discharge, made her life miserable; still, her general appearance was good and this was borne out by the negative pathological findings on general examination. The fistula was located midway between the navel and symphysis in a low median laparotomy scar, which also contained a moderate sized postoperative hernia.

Operation, June 5, 1923. Through an elliptic incision which surrounded the fistulous area, the whole fistula which had already been packed with iodoform gauze was excised with the herniated part of the abdominal scar. The fistulous tract led into a loop of small intestine, the terminal loop of the ileum. The loop was adherent to the tightly embedded uterus. In the freeing of these adhesions a large

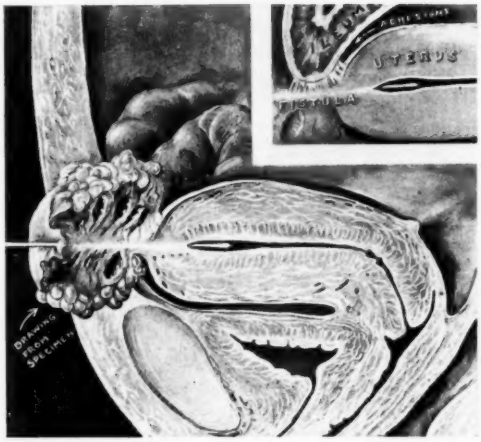

Fig. 5. Case 3. Mrs. M. Postoperative menstrual fistula. Direct communication of the fistula through the endometrial enclosure into the uterine cavity. Also note the intestinal adhesions to the enclosure.

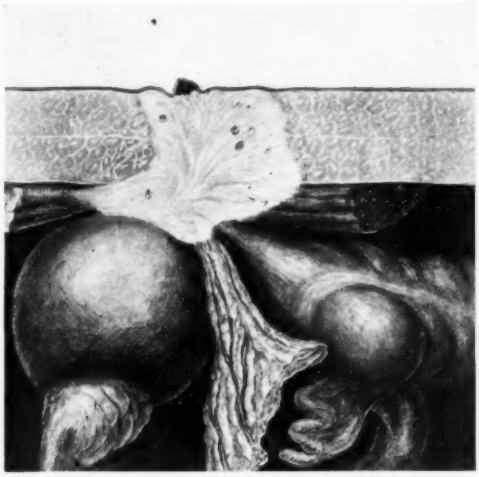

Fig. 6. Case 5. Miss I. Menstruating postoperative fistula with abdominal wall enclosure. Note the cystic areas penetrating the wall and attached to the cystic right ovary. Also note the intestinal and omental adhesions.

left-sided tubo-ovarian abscess was opened, which contained about 50 cubic centimeters of pus without odor. The left tubo-ovarian sac was freed and resected. The intestinal loop was so much damaged and so fistulous in several places that resection was performed. This patient died from peritonitis 15 days after operation.

There are over 40 cases of this type reported in the literature so far, for which the use of the term "menstrual fistula" is justified because of the direct communication of the uterine cavity with the abdominal fistula. Their origin, from the perforation into the uterine cavity after cæsarean section and from deep sutures into the uterus introduced for ventrofixation, is easily understood. As the tubal mucosa either takes part in menstruation or communicates with the endometrium, it is also obvious that tubal fistulæ from salpingectomies or from spontaneous rupture of tubal abscesses and tubal pregnancies through the abdominal wall may also emit menstrual blood.

Our next cases of menstrual fistulæ are of a different and very interesting type, due to postoperative enclosures of endometrial tissue in the laparotomy scars. In 1896, von Recklinghausen (41) perhaps gave the first lucid description of this type of tumor starting from the uterine glandular and muscular tissue, under the heading of adenomyoma and cystadenoma. He considered that these tumors started from enclosures of remnants of the wolffian ducts. The next important publication is by Cullen (17) who considered the origin of this type of tumors as endometrial cells invading the muscular layers from an adenomyoma of the uterus. A third theory of their origin is mainly defended in recent years by Sampson (30, 31, 33) in his many publications. He claims that this type of tumor originates from endometrial cells escaping through the tube during menstruation and implanting themselves, usually in the ovary, but also in the peritoneum and the intestinal serosa. The latter theory has perhaps found the most followers, but cannot explain the origin of all these tumors. Therefore, several authors maintain that these tumors have different causes; that some are caused by transplantation and enclosure of endometrial cells, or the tumor starts from an embryological enclosure (Davis and Cron, 6 and others).

Because of the different views as to etiology, these tumors, which really belong in one

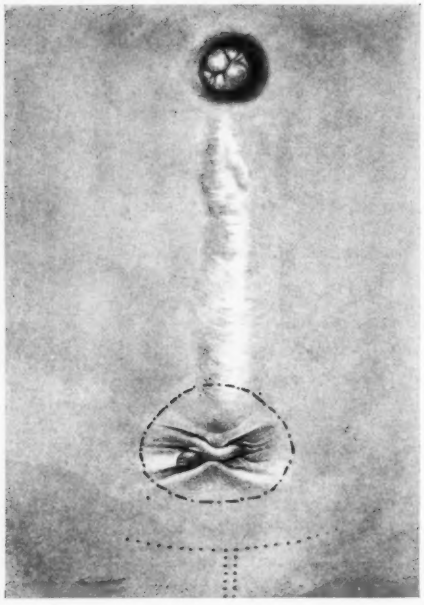

Fig. 7. Case 5. Menstruating fistula in laparotomy scar with the endometrial enclosure.

group, have been described under many names: the "adenomyomas" of von Recklinghausen and Cullen; "ectopic adenomas of uterine type" of Mahle and MacCarty in which nomenclature errors have occurred because aberrant fibroids were included, that is, pedunculated fibroids detached from their pedicles and implanted elsewhere in the abdomen; "wandering endometrioma" of Davies (5); and most recently, "endometrial implants" and "endometriosis" as applied by Sampson and others.

Microscopically, these tumors are found to contain gland structures made up of endometrial cells forming cysts which contain blood. The typical stroma characteristic of uterine mucosa is present and at times uterine muscle cells are also contained in the fibrous stroma of the tumor. In 5 of the 28 (Figs. 2 and 3) cases gathered from the literature by Nicholson (25), these tumors have been found in the uterine and tubal walls originating seemingly from a direct penetration of endometrial cells into the muscular layer of uterus and tube.

Sampson and his followers claim that theoretically all so-called chocolate or tar cysts of the ovary, so well known to every operator, are of endometrial origin. During menstruation, especially in cases in which, because of retroflexion and polyps, the easy exit of the menstrual flow through the cervix is embarrassed, menstrual blood will discharge through the tubal end, as has been actually observed during laparotomies. This blood contains endometrial cells, which preferably become adherent to the surface of the ovary. Small cysts form around the invading graft. The cysts contain endometrial cells and extravasated blood. Deeper invasion of the ovarian stroma leads to the formation of the chocolate cysts (K. V. Bailey). Important is the capacity of these cysts to become adherent and break at times discharging new endometrial cells that may form new deposits on the peritoneum. "If these chocolate or tar cysts of the ovary are all endometrial in origin they are the most frequent endometrial tumors." (Sampson.)

Table I shows the frequency of location of the endometrial tumors (not including the chocolate ovarian cysts and peritoneal implantations).

TABLE I.—LOCATION OF ENDOMETRIAL TUMORS

Author	In laparotomy scar	Umbilicus	Groin	Sigmoid wall	Recto-vaginal septum	Elsewhere
Cullen	2*	1	1	1	1	..
Lochrane	1*	..	..	..	..	..
Semon and Mahle	9	..	..	..	..	..
Allot	2†	..	..	..	..	..
Keen	..	..	..	..	..	1‡
Davis and Cron	..	..	..	1	..	..
Mahle and MacCarty	2	1	2	1	4	..
Miles	..	..	..	..	..	1¶
Heaney	3	..	..	..	1	..
Sharples	..	..	..	1	..	..
Henry	..	..	..	..	..	1§
Our own cases	3‖	..	..	..	2	..
	22	2	3	3	9	3

*After ventrofixation.
†Cæsarean.
‡Bladder.
¶Rectum.
§Labium majus.
‖Round ligament operation.

This table shows that the most frequent location is in laparotomy scars (22 times in 41 cases); then follows the endometrioma of the rectovaginal septum with 9 cases. Of 28 cases

of endometrial tumors in laparotomy scars, Nicholson compiled in 1926, 15 followed ventrofixation, 6 operations on the tubes and ovaries, 1 or 2 each for ruptured uterus, hysterectomy, and round ligament operation, showing the frequency of these enclosures after ventrofixation.

As to the dispute briefly referred to about the origin of these tumors, Sampson's theory is that the endometriosis is due to the escape of menstrual blood through the tubes into the peritoneum and the consequent local reaction produced by endometrial cells carried along with the menstrual blood. In favor of this theory are the following observations:

Jacobson (14) and Dossena (9) produced endometrial implants experimentally in the peritoneum of animals, by scattering endometrial cells into the abdominal cavity. The question as to whether menstrual blood issues from the tube during menstruation has been disputed, but Curtis operated purposely during menstruation and saw, in 3 cases, menstrual blood coming from the tube. Danforth saw the same on at least 1 occasion. Curtis asserts that 16 cases of endometrial implants all had retrodisplacements of the uterus, favoring the back flow of menstrual blood and all had patent tubes. Chocolate cysts occur only in patients with patent tubes (Danforth offers this in favor of the implantation theory), also the most pronounced complaint of such patients is *painful* menstrual periods. Schwartz mentions the fact that the ovary is the favorite organ for implantation of endometrial transplants because it is the nearest organ to the tubal orifice. Davis and Cron (6) observed that in one case the implantation of endometrial cells followed transuterine inflation.

On the other hand, Novak operated on 13 women during menstruation without seeing any menstrual blood coming from the tubes. He found endometrial cells only in 7 tubes of the several hundred examined and these cells had not the characteristics of menstrual endometrial cells. Nicholson does not accept the theory of endometrial transplantations or the origin of embryonic enclosures of this type of tumors. He believes that they are caused by proliferation of the peritoneal epithelium in response to some irritation.

Most likely there are several origins of such tumors. It is reasonable to claim implantation of endometrial cells in the many cases now reported in which endometrial enclosures occur along the tract of ventrofixating sutures in the abdominal wall, or where a cystic ovary connects directly with an endometrial tumor in the scar. Endometrial enclosures in the vaginorectal septum seem to be more of an embryonic enclosure type starting from Wolff's or Muller's ducts. The outcome of the dispute will probably be that tumors in different locations have different origins. Mouat (24) gives 5 varieties of endometriosis:

1. Primary endometriosis; direct invasion of myometrium by endometrial cells; adenomyoma of uterus and tubes.

2. Peritoneal or implantation endometriosis; endometrial cells invade the peritoneal surfaces.

3. Transplantation endometriosis in abdominal scars.

4. Metastatic endometriosis extraperitoneal along the round ligament and in hernia sacs (comparable to metastasis from carcinoma).

5. Developmental misplaced endometrial tissue.

The menstrual discharge from endometrial enclosures in scars of the abdominal wall is not so readily explained as the menstruation from direct fistulæ. At times (Fig. 5) the endometrial enclosure still communicates with the uterine cavity at the place of ventrofixation, or with a cystic ovary (Fig. 6). Here again the menstrual discharge through the fistula is understood. In our third case of this type and most other cases in the literature, such connection between fistula, wall enclosure, and uterine cavity or ovary, was not found. Hence we must come to the conclusion that endometrial enclosures in a laparotomy scar and elsewhere are apt to secrete and discharge blood at intervals. This indeed is true and borne out by actual records of cases and the anatomy of the enclosures.

Menstruation or menstrual symptoms from these tumors are mentioned frequently in the literature. Some of Cullen's cases gave a history of enlargement of the umbilical adenomyoma at the time of menstruation and one of his patients noticed a serous discharge dur-

ing catamenia. Mahle and MacCarty describe an adenoma of the umbilicus, a hard bluish tumor that broke open and discharged bloody serous fluid. This tumor became quite painful at the time of menstruation. Nicholson mentions that menstruation was often marked by increase in the size of the tumor and pain and in 3 cases was accompanied by a bloody discharge from the surface of the tumor. Mahle and Carpenter give 2 cases of abdominal scar enclosure and state that the lump was painful at the time of menstruation, also the two inguinal cases had the same complaint, and so did the one with the adenomyoma in the rectovaginal septum. One of them had a polypoid tumor formation raising the vaginal mucosa. "The occasional relation to menstruation of pain and swelling of the tumor or, less frequently, a bloody discharge should be very suggestive of adenomyoma." Nicholson calls these tumors "accessory uteri in build as well as function." Heaney (11) states that usually the nodules swell and are painful during the menstrual period and afterward for several days. Lochrane, (19) under the heading of "Endometrial Adenomas," describes a postoperative cyst in the abdominal wall that discharged blood. Sampson (31, 33, 30) also states that "endometrial implants react to menstruation, pregnancy, and menopause as does the mucosa lining the uterine cavity." F. E. Keene's case of "endometrial invasion of the bladder" healed after bilateral ovariectomy. In criticizing this report Polak adds that endometrial tumors atrophy when ovarian stimulus ceases. Even an endometrioma of the sigmoid caused dysmenorrhœa (Sharples, 38). Heaney (11) mentions in reference to the endometrial tumors in the rectovaginal septum that 2 of this type of tumor became fistulous in the vaginal vault producing polypoid-like formations. One of ours did this also.

From our own observation and from the data in the literature, it is evident that pain as well as bloody discharge are outstanding symptoms of endometrial tumors.

Our 5 cases of endometriosis, 3 in abdominal scars, 2 in the rectovaginal septum, had menstrual or near menstrual symptoms from their endometrial tumors. These cases follow:

CASE 3. Mrs. G. M., 27 years old, admitted to Harper Hospital, February 1, 1924. Complaint: periodic discharge of blood from a fistula in the abdominal scar. She had been operated upon 6 years previous: removal of left tube and ovary through a median laparatomy. A fistula followed this operation and discharged somewhat all the time and became more painful with increased discharge at the time of the menstrual period. Several times this fistula had to be reopened to evacuate painful menstrual retention. The diagnosis was a menstrual fistula.

An elliptic incision surrounding the fistula and scar was made. In the wall was found a typical endometrial enclosure with bloody spaces. The fistulous tract led to the adherent fundus uteri. Several intestinal adhesions were present and adherent to the fistulous tract. The fistulous tract was excised from the uterus. The small wound of the uterus was sutured. The abdomen was closed tight with special attention to the fascia to avoid further formation of hernia.

CASE 4. Mrs. A. S., age 35, was first seen on July 22, 1926. She had had one miscarriage at the age of 24; no children. She was operated on, when 31 years old, in a Toledo hospital. A uterine tumor, right tube, and ovary were removed. The wound was drained. In the scar of this operation, a tumor developed and grew slowly in size. The tumor was tender and very painful during menstruation. She said: "It feels as though it would burst." At such times some dark bloody discharge stained her underwear over the tumor. Profuse menstruation occurred every 3 weeks.

The otherwise healthy appearing woman had a low median laparotomy scar. In the lower angle, there was a round, raised, dark colored, firm, very tender mass, cystic in places, 5 centimeters in diameter, adherent to skin and to fascia and muscles. In its center was a small cystic area, moist on its surface from some brownish discharge.

Vaginal examination showed the uterus large, adherent to the scar in the region of the tumor. A diagnosis of abdominal wall enclosure with a menstrual fistula was made.

At operation, October 18, 1926, an elliptic excision of old laparotomy scar including a cavernoma-like tumor 2 inches in diameter was made. The tumor was found penetrating the whole wall and connecting with an omental string going to the fundus of the uterus. Very diffuse omental adhesions covered up the whole pelvis. After they were separated, a 2-fist-sized fibroid uterus developed. The fibroids were posterior, close to the cervix. The right adnexa had been removed at a previous operation. The left hydrosalpinx with cystic ovary was found. Supracervical hysterectomy was performed with removal of left adnexa, a small ovarian stump being left. Freeing and toilet of all omental adhesions were carried out. The pathological finding of the tissue removed was adenomyoma of the abdominal wall. The patient was cured.

CASE 5. Miss V. I., 22 years old, was seen in May, 1927. A left oöphorectomy had been performed 6 years previously, for a pelvic inflammatory condition. In the lower angle of the laparotomy scar there was a hard irregular enclosure that had required lancing during the past year or broke to discharge some blood. The tumor was always painful during menstruation and the pain was relieved by opening one of the blood cysts that formed. This patient was operated upon for menstrual fistula on May 25, 1927 (Figs. 6 and 7).

The whole endometrial mass was dissected loose. It penetrated diffusely into the right rectus muscle and communicated with an adherent cystic right ovary. The appendix also was involved in the adhesions. Excision of the whole mass and resection of the cystic ovaries led to a complete cure.

A history of our 2 cases of rectovaginal enclosures follow:

CASE 6. A Miss H. M., a nurse, who complained of pressure on the rectum and pain which was so much worse during menstrual periods that she had to take anodynes. A small tumor formation in the posterior vaginal vault could be felt. On laparotomy, a fibromatous tumor was found in the rectovaginal septum containing bluish cysts. It looked like a rudimentary duplication of the uterus. The tumor was then also exposed through the vagina and some chocolate fluid was removed from a hæmorrhagic cyst. Complete excision of the mass was not done on account of the intimate relation to the rectal wall. Following this operation, dark fluid was discharged from these vaginal cysts and these became very painful during menstruation. The pain was relieved sometimes by puncturing the small cysts in the vaginal septum.

CASE 7. Mrs. C. G., 35 years old, was referred for a tumor similar to that in Case 6, palpable in the rectovaginal septum, and very painful during menstruation. We thought we had to deal with a tubo-ovarian cyst, but at operation we found the same type of nodular mass with cystic enclosures—an endometriosis of the rectovaginal septum.

The literature and our cases mentioned show that tumors occurring in laparotomy scars may be identical with endometrial tumors which are found elsewhere on the surface of the peritoneum, in the rectovaginal septum, sigmoid, etc. These tumors have arisen from 2 to 25 years after laparotomies (Nicholson). They always seem to be restricted to the lower half of the abdominal wall. It has been established that these tumors of the wall are identical in structure and cyclic function with those of the uterine mucosa. (Lemon and Mahle.) Moreover it is very probable that in some cases there has been direct transplantation of uterine endothelial cells by means of the needle and suture in ventrofixation. It is also significant that menstrual fistulæ are frequently complicated by fæcal fistulæ; fistulæ after cæsarean section usually followed unsatisfactory suture of the uterus.

Fæcal fistulæ were present, in addition to the menstrual in Puccioni's second case and in Bouzol's case. In Deverre's case a gangrenous appendix was involved in the adhesions around the fistula. Of our patients, Case 1 and Case 2 had intestinal fistulæ with the menstruating fistula. Intestinal adhesions without fistula are mentioned in Puccioni's first case and were present in Cases 3, 4, and 5 of our series. All of ours had postoperative hernias in the scars around the fistula, just as mentioned in Puccioni's first case.

All these facts show that a certain prophylaxis against menstrual fistulæ is possible and coincides usually with modern surgical rules for pelvic operations. Cæsarean section should be done in the low subperitoneal part of the uterus; the peritoneal (bladder) flap covering the uterine suture and low location of this scar will prevent its adhesion to the wound in the abdominal wall. Such adhesion is favorable to the formation of a uterine fistula. If a high cæsarean section cannot be avoided, proper suturing of the uterus will prevent to some extent the formation of such fistulæ. In dealing with tubal and uterine stumps, good peritonealization and oversuturing of raw surfaces will prevent adhesions between wall and uterus or tubes.

Ventrofixation in the presence of pelvic peritonitis seems to be especially prone to be followed by menstrual fistula. If the fixating suture penetrates into the uterine cavity and fixates the fundus to the laparotomy, an excellent chance for menstrual fistula is created. Intestinal adhesions to ventrofixations with kinking, breaking down of the kinked loop, and formation of a fæcal fistula, will create septic conditions around the ventrofixating sutures, again easily leading to uterine perforation and fistula. Ventrofixation by deep sutures through the fundus in inflammatory conditions is best avoided and, in any case, generally has not much in its favor.

Wall enclosures are created when raw uterine, tubal, and ovarian surfaces come in contact with the abdominal wound. The covering of such raw surfaces, uterine stumps, etc., will prevent formation of abdominal wall enclosures and thereby the production of menstrual fistulæ. Real implantation of detached uterine or ovarian tissue in the scar is rare and is obviously avoidable.

In operating for these fistulæ, the presence of a fæcal fistula or the injury to densely adherent intestines renders the prognosis of such operations somewhat more serious than one would think. Death in Case 2 was from peritonitis following the operation, no doubt due to infection from the fæcal fistula. At a certain clinic, in view of several unsuccessful attempts to close the fistula, further operations were declined, no doubt wisely, as the outcome of our operation indicates. However, the discomfort of this patient from the still complicating tubal abscess demanded interference. Because of difficult adhesions or the presence of a fæcal fistula, the operation is serious. Then, too, if the adhesions prevent exposure and resection of the fistulous uterus or tube, the fistula is likely to recur (Case 1).

Radical operation for a fistula should mean total excision of the fistulous tract or endometrial scar enclosure in continuity with the uterine fistula, or ovarian cysts, by hysterectomy, total or partial, or ovariotomy, as the case may be.

CONCLUSIONS

1. Menstrual fistulæ are fistulæ in the abdominal wall characterized by a periodic discharge of menstrual blood.

2. They rarely originate from spontaneous rupture of a pus tube or an extra-uterine pregnancy through the abdominal wall; usually they follow operations, cæsarean sections, ventrofixations, and salpingo-ovariotomies and then either connect directly with the lumen of a tube or the uterine cavity, or connect with menstruating endometrial enclosures in the laparotomy scar.

3. Frequent complications with extensive intestinal adhesions and fæcal fistulæ occur and render the operation for them somewhat difficult.

4. The name "menstrual fistula" and perhaps also "menstrual tumor" for postoperative and endometrial enclosures is proposed to emphasize their outstanding symptoms just as fæcal and urinary fistulæ describe an entity.

5. Menstrual fistulæ and the endometrial tumors are painful and discharge more or less blood at the time of menstruation.

I wish to express my indebtedness to Dr. Plinn F. Morse, of Harper Hospital, for the pathological examinations and photomicrographs.

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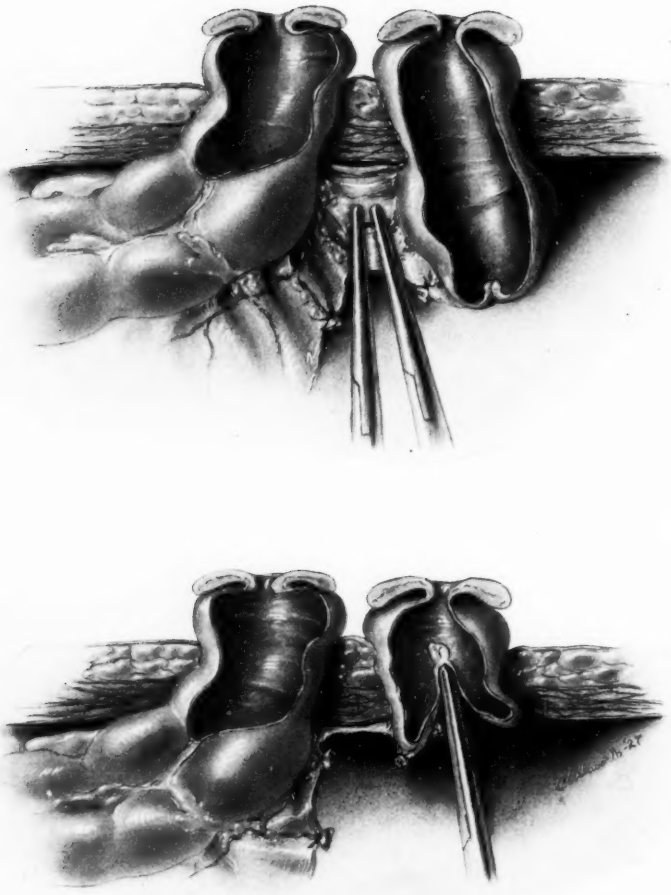

Fig. 14. Sagittal views showing the ligation of the mesentery and the beginning invagination of the lower end of the bowel prior to its removal as a third stage of the operation.

The Technique of the Anterior Resection of the Rectosigmoid.—Fred W. Rankin

CLINICAL SURGERY

FROM THE DIVISION OF SURGERY, MAYO CLINIC

THE TECHNIQUE OF ANTERIOR RESECTION OF THE RECTOSIGMOID[1]

By FRED W. RANKIN, M.D., F.A.C.S., Rochester, Minnesota

RECTOSIGMOID is an anatomical name for a portion of the gastro-intestinal tract which, strictly speaking, represents the continuation of the pelvic colon above into the rectum below, but which, surgically speaking, represents a division of the large bowel which includes not only the last 5 centimeters of the sigmoid but the upper 5 centimeters of the rectum proper. It is the smallest part of the large intestine and possesses a mechanism whereby the fæcal current is retarded or stopped so that normally the rectum is practically always empty. The rectum proper begins at the third sacral vertebra and extends to the top of the prostate in the male and to the perineal body in the female, landmarks which correspond with the beginning of the anal canal. At the point at which the sigmoid enters the top of the rectum from the left side, the direction usually changes, thus making an angulation as the peritoneum-covered colon merges into the retroperitoneal portion of the pelvis. The narrowing of the bowel at this point is not the only anatomical peculiarity of the anastomosis: there is a distinct difference in the mucous membrane of the two divisions of the large bowel, that of the sigmoid being thrown into rugæ and appearing as distinct from the rectal mucosa as the gastric mucosa is distinct from the duodenal mucosa at the pylorus. This change in the appearance of the mucous membrane is characterized by an increased blood supply and a greater freedom of this internal coat of the bowel. There is no change in epithelium at this point in the gastro-intestinal tract such as is noted lower, in the anal canal, which is lined with pavement epithelium and has no mucous glands (Fig. 1).

It has not been definitely proved, despite frequent assertions, particularly in discussing the etiology of such vague diseases as megacolon, that there is a definite sphincteric mechanism at the rectosigmoid. Unquestionably there is a distinct narrowing of this portion of the intestinal tube. Reeves, in 1917, dissected out the rectum and rectosigmoid in 46 cadavers and found that a terminal constriction was present in 86 per cent, and that in two instances the narrowing was so definite as to reduce considerably the caliber of this portion of the bowel. More recently, Martin and Burden, in discussing the sphincteric action of the rectosigmoid, observed that of 31 specimens examined 12 showed a distinct and abrupt transition in the appearance of the mucous membrane between the rectum and sigmoid; in the others the transition was more gradual at varying distances up to 31 centimeters from the anus. Regarding the musculature at this particular point, however, they assert: "As a rule, the sigmoid has a well-developed musculature exhibiting no local increment of circular fibers to suggest an anatomical sphincter, nor is there a constant perceptible narrowing at the rectosigmoid juncture." Anatomically this is a favorite site for neoplasms and its inaccessibility is proverbial among surgeons. Too high to be attacked readily by a posterior type of operation, it is at the same time too low to be easily accessible by the abdominal route except in cases in which the anatomical conformation renders the difficulties less marked.

The acceptance of the postulate that all carcinomata that are extirpable should be dealt with radically not alone by their removal but by removal of the contiguous gland-bearing tissues as well, predicates a formidable procedure in dealing with malignancy in this situation. The lymphatic drainage involved in carcinomata of the rectum that are above the anal canal has been excellently worked out by Miles, who divides the lymphatics which drain the rectum into intramural and extramural groups. The intramural group is found in the rectal wall; one plexus is in the submucous tissues and the other is between the muscular coats. The spread in this group is unquestionably limited, although there must be some spread in a small number of cases by this route. The extramural lymphatics are the more

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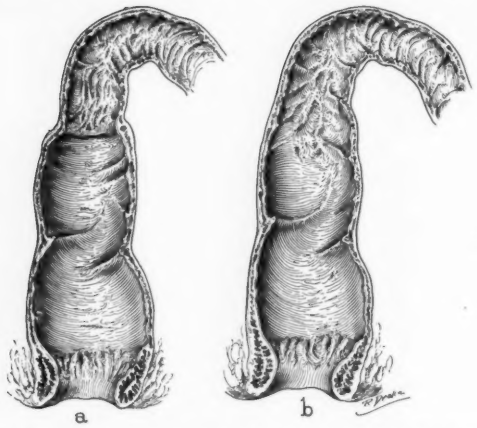

Fig. 1. Occasionally a sharply defined sigmoid juncture is seen as in *a*. The transition is usually gradual as in *b*. (After Martin and Burden)

important from the surgical standpoint and are divided into zones as follows (Fig. 2):

1. The zone of downward spread which includes the perianal skin and ischiorectal fat and the external sphincter. This site is especially vital in cases of carcinoma of the anal canal. Only because of its anastomosis with the other zones need it be considered if the carcinoma is higher in the bowel.

2. The lateral zone which includes the lymphatics between the levator ani muscles and the pelvic fascia and structures, the prostate gland, the base of the bladder, the cervix uteri and the base of the broad ligaments in women, and the internal iliac lymphatics.

3. The upward zone which includes the pelvic mesocolon and the lymphatics situated at the bifurcation of the left terminal iliac artery as well as the aortic nodes. Miles considers the zone of upward spread the most significant, an opinion in which many of his contemporaries, both foreign and American, concur.

In a recent brilliant and exhaustive article on carcinoma of the rectum, Pfeiffer notes the work of Villemin, Huard, and Montagne, who offer a simpler anatomical division of the rectum on the basis of lymphatic distribution whereby the portion above the lowest valve of Houston is designated as the upper or pelvic rectum, and the portion below as perineal rectum. Lymphatic injections in the lower part of the rectum spread upward to the last valve of Houston, but not beyond, while injections above the valve spread downward but are arrested at the valve. The

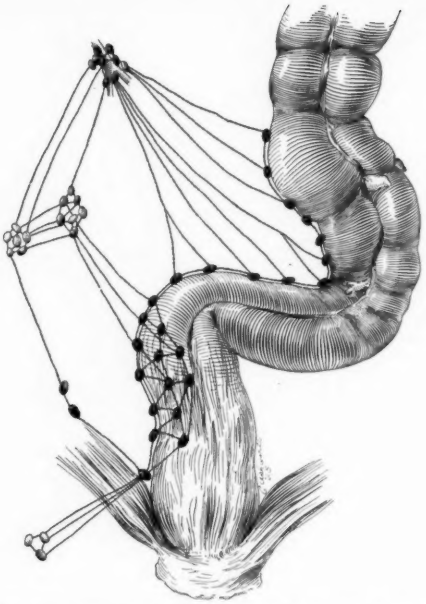

Fig. 2. Extramural lymphatics of the rectum and sigmoid. (After Miles)

point is made clear that there is no such limitation at the rectosigmoid, the efferent vessels being divided into groups corresponding to the arterial supply of the part, the superior lymphatics following the superior hæmorrhoidal vessels and anastomosing with the abdominal group of lymphatics, while the two lower groups, the middle and inferior, pass to the pelvic and lateral zones but anastomose with the inguinal and intra-abdominal lymphatics. These authors deduce that carcinoma of the upper part of the rectum should be removed by an operation exclusively abdominal; obviously the rectosigmoid is included in this classification. The drainage of lymphatics, as Broders puts it, is "toward the mediastinum" and for this reason, removal of the lymphatics behind the growth perhaps is not always essential in dealing with malignancy. That these tissues should be removed by wide radical resection compatible with a reasonable mortality rate and a satisfactory functional result is the aim of any operative procedure dealing with neoplasm in this situation.

Undoubtedly many cases of malignancy of the large bowel and rectum are best dealt with by graded maneuvers. When it is considered that the average patient with rectal carcinoma (in

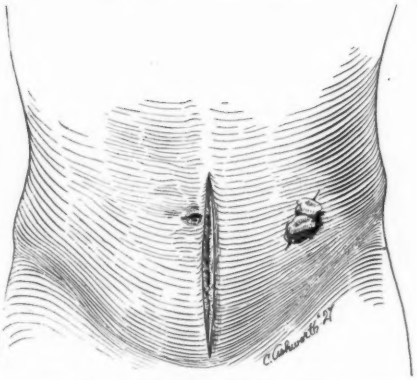

Fig. 3. Median line incision extends above the umbilicus giving ample exposure. The colostomy is shown and should be done 2 weeks in advance of the resection.

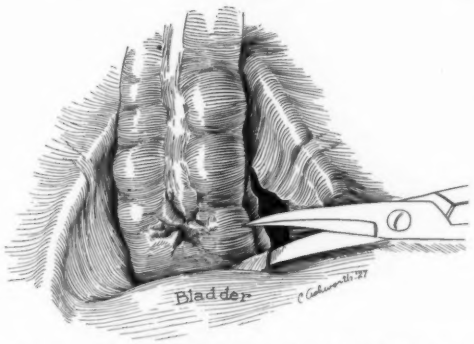

Fig. 4. The peritoneum is incised on both sides of the bowel, the incision running down to the bladder. This is a bloodless dissection and permits the identification of both ureters before the operation is carried further. Ample peritoneum is saved without difficulty in the majority of cases for the peritonealization of raw surfaces.

this group carcinoma of the rectosigmoid is likewise included) presents himself after symptoms have been present for a year, the low percentage of cases accepted for any type of operation except palliation is not surprising, nor is it strange that many patients who are submitted to the two-stage or three-stage operation are able to withstand more radical procedures with better end-results than if the operation were undertaken at a single stage.

Chronic obstruction of the large bowel is a vital factor because of the accompanying rapid debilitation, anæmia, and desiccation. The chronic absorption, not only from the content of the intestinal tract but from the large ulcerating and infected surface of the growth, causes a lowered physiological state and this has direct bearing on the outcome of any type of operation. Peritonitis, bronchopneumonia, and other post-operative complications which result even from simple operative procedures instituted for the relief of obstruction or for palliation are directly the result of intoxication due to obstruction. Consequently, one of the principal aims of operation is the eradication of the obstruction, which perhaps is the most important rehabilitation measure indicated in the majority of instances and is partially accomplished before the first stage of the operation. Although it may be too radical to postulate that all carcinomata of the rectosigmoid and rectum should be operated on by the graded operation, certainly such a procedure is required in the greater number of cases and only in selected cases should the more formidable, but highly desirable, one-stage abdominoperineal resection be undertaken. In this selected group of cases the abdominoperineal operation performed by the technique of Jones, of Boston, is ideal. A graded abdominal or abdominoperineal resection permits of more radical procedures with removal of a wider area of infected tissue in a case in which otherwise the risk would be considerably greater. In the absence of metastasis to the liver and fixation to adjacent structures, immobility is unquestionably the most significant criterion in the decision as to whether the growth is removable and this immobility is, I believe, more often the result of inflammatory than malignant changes. Given a drainage operation which permits local treatment and the institution of measures to reduce inflammation, one not infrequently finds that a radical secondary operation may be carried out satisfactorily in cases which, at the first stage, were deemed unsatisfactory for resection.

PRE-OPERATIVE PREPARATION

The isolation of patients with surgical diseases of the colon and rectum under co-operative management in the Mayo Clinic has permitted not only proper pre-operative preparations to be instituted but, with increasing experience, has permitted better selection of cases for different types of operation. The rehabilitation measures instituted consist of (1) adequate cleansing of the gastro-intestinal tract; (2) supportive measures, such as blood transfusion, increase in fluid intake, and general measures to increase the patient's resistance; (3) institution of local measures which reduce the inflammatory reactions around the growth; (4) proper dietary measures, and (5) institution of drainage, by colostomy, preliminary

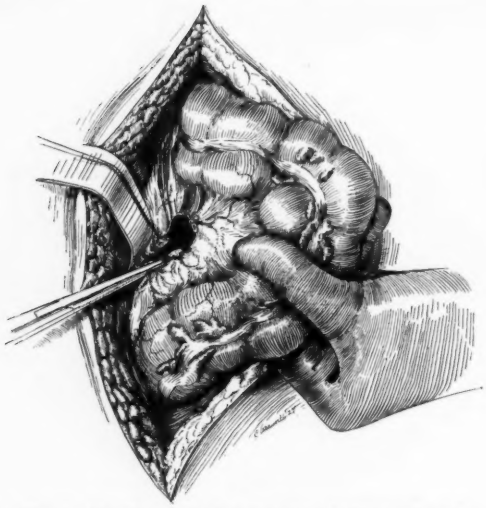

Fig. 5. Ligation of the inferior mesenteric vessels at the promontory of the sacrum above the left colic branch is the first step to insure control of hæmorrhage and permit a dry field for the subsequent steps of the operation. The peritoneum is incised over the vessels and a finger put around them to isolate them so that they may be clamped individually without too much tissue being caught. Meanwhile, the bowel should be held toward the left lateral abdominal wall and the ligation made in the median line.

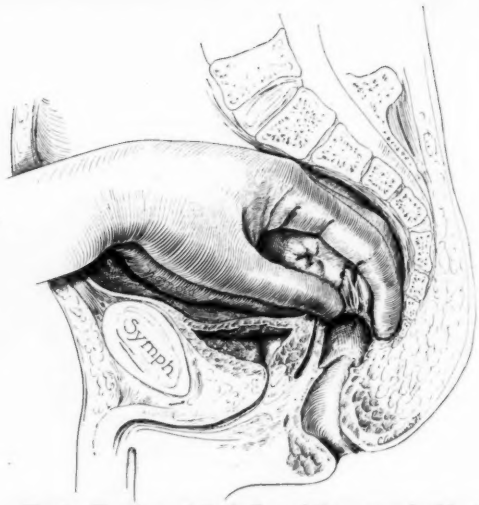

Fig. 6. Cleaning out the hollow of the sacrum by blunt dissection, which is easily accomplished after ligation of the mesenteric vessels and mobilization of the peritoneal flaps, usually with only slight oozing. The hand introduced at the promontory of the sacrum is carried forward until the fingers slip off the coccyx. By means of blunt dissection the incision is subsequently carried forward on each side to the bladder in the male and in the female to the utero-sacral attachments.

to subsequent resection. The study of these cases and a comparison of immediate results over a short period have shown convincingly that co-operative group management pre-operatively and postoperatively, with proper selection of anæsthetic, and a graded operative maneuver, have added materially to the immediate satisfactory operative results.

The routine pre-operative preparation of the bowel itself has consisted of (1) the institution of drainage prior to resection; (2) the administration of small doses of castor oil in varying amounts to within 48 or 96 hours before operation, and (3) cleansing enemas twice daily until 24 hours before the operation with large amounts of water until it returns clear, and (4) during the day prior to operation, paregoric in divided doses of from 1 to 2 drams every 4 hours until 4 doses have been given. This routine almost invariably results in a clean, empty bowel and the administration of the narcotic during the last 24 hours has had a decided sedative effect on peristalsis. A diet free from residue and consisting largely of fruit juices and candy has been found satisfactory. Increase in weight frequently has resulted, and nutrition has always been adequately maintained.

COLOSTOMY

Perhaps the most important advance in the treatment of carcinoma of the rectum and recto-sigmoid has been the usual tendency to accept permanent colostomy as a necessary step in the procedure. Whether the operation is performed at one or two stages, there is small reason for debate of the fact that most patients are better off with the colostomy opening on the anterior abdominal wall where it may be more satisfactorily attended to than posteriorly on the sacrum. In performing colostomy, I prefer to explore the abdomen through a split-muscle incision, palpating the liver, aortic lymph nodes, and the growth, in the order named, and determine the relative fixity of the growth in the absence of metastasis. The artificial anus is made as high as possible in the sigmoid or colon. The colon is fed back into the abdomen until its fixed point is reached and here an opening in the transverse mesocolon permits drawing under it of at least two layers of the abdominal wall: the skin and peritoneum. The small fossa lateral to the colon between its mesentery and the parietal peritoneum is shut off by a purse-string suture to prevent herniation and obstruction from loops of the small

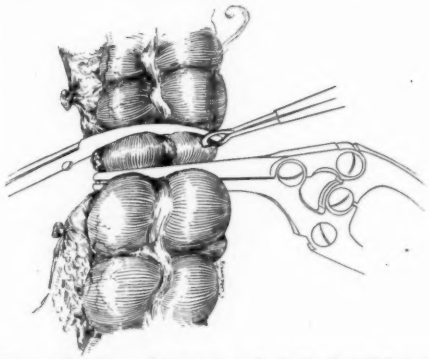

Fig. 7. Dividing the upper end of the bowel between clamps with cautery.

bowel which might pass behind it. As the colon is fed back into the abdomen, a taut point is reached which also prevents subsequent herniation of the mucous membrane of the bowel and makes it much easier to care for. I do not believe that sutures should be placed in the wall of the bowel. Occasionally fæcal fistula results in spite of the care taken not to penetrate the lumen, and if the peritoneum is drawn snugly around, there is small question of necessity of the sutures. The peritoneum and the skin are sutured as separate layers under the bowel. A few interrupted sutures in the aponeurosis of the external oblique are all that are necessary, except the subsequent approximation of skin. I have seldom observed hernia as a result of this type of operation. Control is likewise satisfactory so long as the bowels are constipated.

The colostomy is allowed to remain closed as long as the patient does not complain of gas distention, and frequently gas passes over the stoma and out by rectum for as long as 10 days. Usually, however, one must cut across the bowel or at least puncture it to obviate painful distention. One may make this incision any time after 48 hours, up to 7 days, and then institute through-and-through irrigations with the idea of cleansing the lower loop of the bowel and reducing infection as much as possible in preparation for the secondary resection. Either physiologic sodium chloride or weak permanganate of potash solution is satisfactory for irrigation. Probably the removal of the content of the bowel and the thorough washing of the ulcerated and infected area account for the reduction in inflammatory reaction, rather than the use of any particular medicament which may be placed in the solution. At the same time, rehabilitation measures are forced and the patient

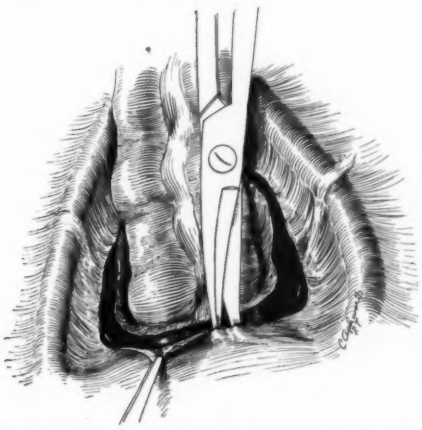

Fig. 8. Separating the bladder from the rectum in the male by dividing the peritoneal fold which attaches them.

comes to operation in an infinitely improved state from the delay of two weeks and the institution of drainage.

TECHNIQUE OF RESECTION

Usually it has been found advisable to wait from 10 days to 2 weeks after the preliminary colostomy has been performed before the second maneuver of the resection is carried out. The abdomen is opened through a long median-line incision which extends to the left of the umbilicus and about 2.5 centimeters above it (Fig. 3). To prevent contamination as much as possible, the stoma is sealed off before operation is begun and

Fig. 9. Division of the lower end of the bowel between clamps with cautery.

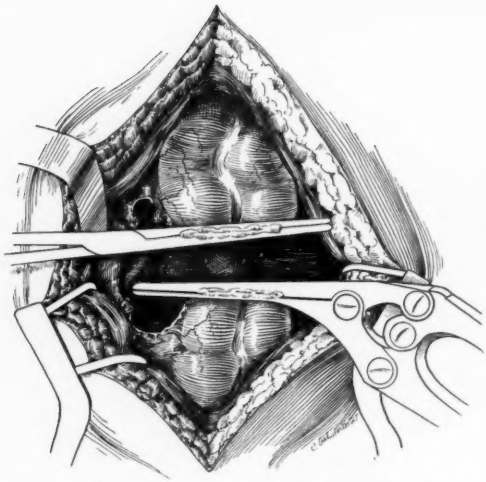

Fig. 10. Operative field showing the segment of the bowel to be removed. In this instance the lower segment is longer than usual and re-establishment of the lumen may be considered. This is a questionable step, however, and should be done in only selected cases.

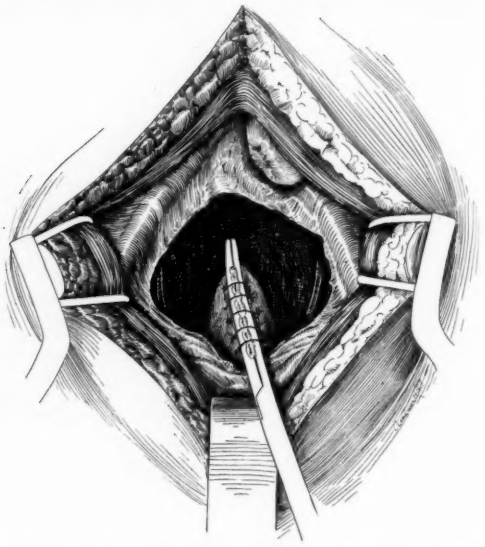

Fig. 11. Operation is complete except for inversion of the rectal stump and peritonealization of the raw surfaces. Inversion of the rectal stump is accomplished by over-and-over suture without difficulty except when the stump is excessively short, then a clamp may occasionally be left on.

I believe it is rarely a source of contamination except by superficial wound contamination which is a rather constant accompaniment of any procedure carried out on the large bowel. After the abdomen has been opened and its contents in the upper quadrants, except the pelvic colon and contents of the pelvis, packed away, the initial step to insure satisfactory hæmostasis is ligation of the inferior mesenteric vessels near the promontory of the sacrum (Fig. 4). The inferior mesenteric artery should be ligated between the superior hæmorrhoidal and the left colic branches in order to preserve adequate vascular nutrition to the left colon. The whole of the descending colon sigmoid, and upper part of the rectum derive their blood supply from this artery. It is fairly constant in its distribution, save only for its anastomosis with the superior mesenteric which fails occasionally and results in necrosis of the left colon. The arteries of the sigmoid, which are branches of the inferior mesenteric vessel, anastomose with the superior hæmorrhoidal and left colic arteries and are not sufficiently disturbed to interfere with the blood supply of the upper part of the sigmoid after a ligature has been placed between the left colic and superior hæmorrhoidal vessels (Fig. 5). In ligating the left colic vessel, one first retracts the colon toward the left side and incises the peritoneum of its mesentery over the vessel. This exposes the vessels readily, and they may then be isolated on a finger. Careful manual

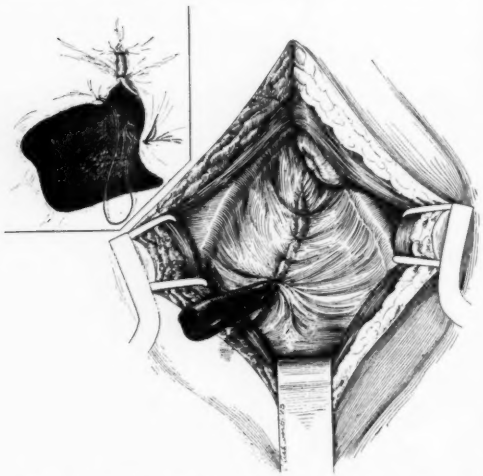

Fig. 12. Peritonealization of pelvis complete. A Penrose drain in the angle takes care of the serous accumulation of the first 48 hours. All raw surfaces are adequately covered. The inset shows closure of the peritoneal flaps which were provided for in the mobilization of the sigmoid and which are sufficient to cover all raw surfaces.

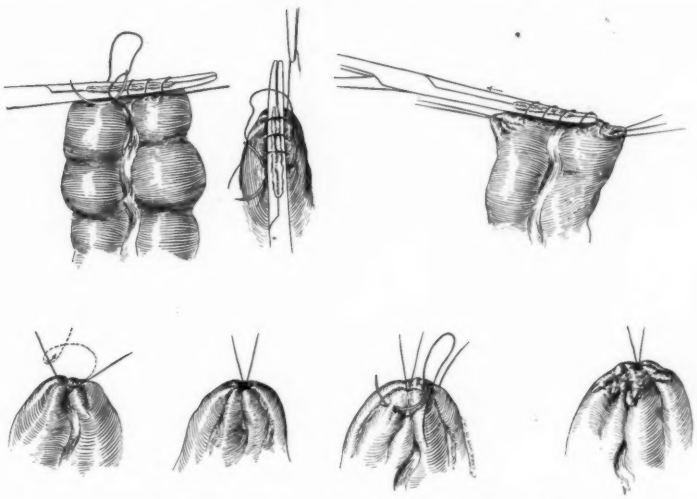

Fig. 13. Steps in the closure of the upper end of the bowel, which is really the blind loop on the colostomy. This is inverted satisfactorily and peritonealized if it is to be left. Ordinarily, it is better removed as is shown in Figures 15 and 16.

manipulation of the vessels, isolating them together, is, I believe, preferable to elevating them on an aneurism needle or other instrument and is less rarely accompanied by tearing into the vein with resulting venous hæmorrhage. The vessels should be freed of fat and carefully ligated twice to prevent them from retracting into the mesentery with an ensuing hæmorrhage or at least a large and undesirable hæmatoma. The initial incision on the right side in the peritoneum of the mesentery of the pelvic colon is now carried forward to the bladder with retraction laterally to expose the right ureter. A similar incision is made on the left side after the sigmoid is retracted toward the right, and the left ureter is likewise identified (Fig. 6). I believe the identification of the ureters is an important step and if possible should always be observed.

When both ureters have been identified and the blood supply has been ligated, the dissection of the hollow of the sacrum follows easily and is readily done with the hand. If the hand is introduced at the point of ligation of the inferior mesenteric, blunt dissection may be carried back to the fascia covering the hollow of the sacrum and the dissecting fingers carried forward and downward until they may be felt to jump off the end of the coccyx. This is about as low as posterior dissection may be done. It is surprising how infrequently there is any bleeding accompanying this step. Except for a few veins which are sometimes troublesome, whether one does an anterior or posterior resection, there is rarely any bleeding, and never any of consequence. A hot salt pack placed in the hollow of the sacrum, once its contents are dissected, controls any oozing which may be present.

The next step in the procedure is to free the sigmoid from its peritoneal attachments to the bladder. Starting on the right side, with scissors dissection I cut across the peritoneum which joins the two viscera and separate them readily. If the ureters have been identified previously, there is no question of injury either to them or to the base of the bladder itself (Fig. 7). Occasionally a sigmoidal growth will be found attached to the posterior wall of the bladder, and it is necessary to take away the outer coats of this viscus in the dissection. If the mucous membrane of the bladder is not opened, there is no complication from this step. After the attachments of the vesicosigmoid have been separated by blunt dissection, laterally and anteriorly, the rectosigmoid and upper part of the rectum are freed down to a point within from 5 to 7.5 centimeters of the anal orifice (Fig. 8). It is surprising how far down one may carry this dissection and remove practically the whole of the rectum with the sigmoid, leaving only a small stump. It is advisable to do the complete dissection in most instances before the sigmoid is cut across at its upper end; yet when the growth is attached and dissection is some-

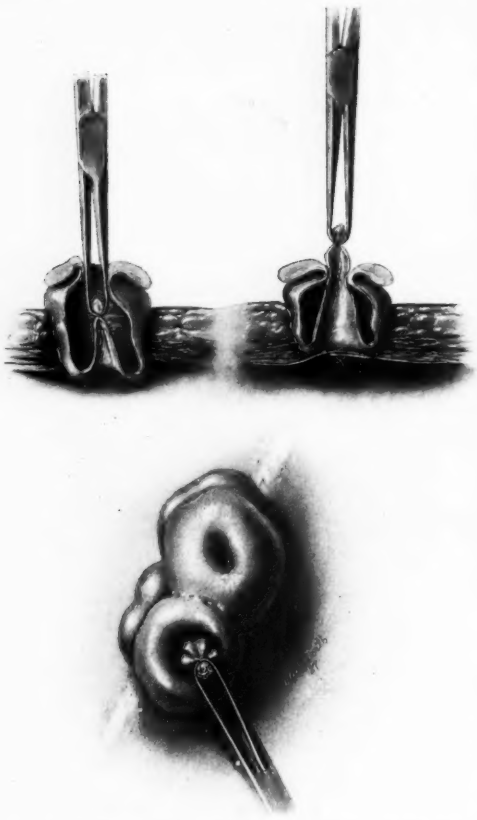

Fig. 15. Further steps in the invagination of the colostomy stump. The lower picture shows it being completely everted and drawn out through the abdominal wall to be removed with cautery several days later.

what difficult it may be better to divide the sigmoid and use the upper portion as a tractor for exposure and to aid in the completion of the dislocation.

The bowel is now removed between two clamps at both ends (Fig. 9). In this manner there is a large amount of bowel sacrificed and all the gland-bearing tissues, the upper and lateral lymphatic zones of Miles, are removed with it. There remains only the problem of furnishing peritoneum for the pelvis, of making a new pelvic floor, of turning in satisfactorily the lower end of the rectal stump, and of dealing with the distal end of the sigmoid beyond the stoma (Fig. 10). These three steps are more easily accomplished than would be expected, particularly the step dealing with the rectal stump. Although this end of the bowel is deep in the pelvis and far from accessible, one may, by using an over-and-over type of suture, such as is used in dealing with the duodenal stump following gastric resection, turn it in satisfactorily and place accurately at least two layers of sutures (Fig. 11). This is usually done with tannic acid catgut on curved needles, re-enforcing with a few interrupted silk sutures. The pelvic peritoneum has been mobilized at the ligation of the inferior mesenteric vessels in such a manner as to leave ample reflection on either side to join in the median line, so that a new floor for the pelvis is made. I have not encountered difficulty in saving enough peritoneum satisfactorily to close over the male pelvis, and in the female pelvis it is a relatively much simpler procedure because the uterus and adnexa may if necessary be drawn over and sutured to the promontory of the sacrum in case there is a gap in the peritoneum (Fig. 12).

There is the disadvantage, however, in both instances, of a large dead space in which serum will certainly collect and which is potentially infected from the manipulation of the bowel. This space is always drained but not for long or very effectively. Two small rubber tissue drains are usually ample, or at most, one cigarette tube. In the female, drainage is much simpler and is always secured through the vagina. This reduces the mortality of operation considerably over that of the male, when drainage must necessarily be secured through the abdominal wound (Fig. 13). The question of draining through the rectal stump is one to be distinctly deprecated in any case. The upper end of the sigmoid or the small blind pouch which lies below the stoma may be dealt with satisfactorily in two ways, either by removal or leaving it *in situ*. I usually leave it after invaginating with catgut and silk and putting over whatever fat tags are conveniently near, but occasionally it has seemed advisable to remove it. I do this after ligating the blood supply up to the peritoneum and by simply invaginating it on itself through the abdominal wall and leaving it for subsequent removal, when it is adequately sealed off (Fig. 14). After the operation has been completed, an assistant, with an instrument attached to the end of the blind pouch, pushes it into itself and out through the abdominal incision where the surgeon may grasp it and by traction bring it entirely out, leaving it attached so that there will be no contamination from this step. A few sutures placed in the peritoneum behind it preclude any difficulty from contamination (Fig. 15, frontispiece). The abdominal wound is now closed and the stump is allowed to

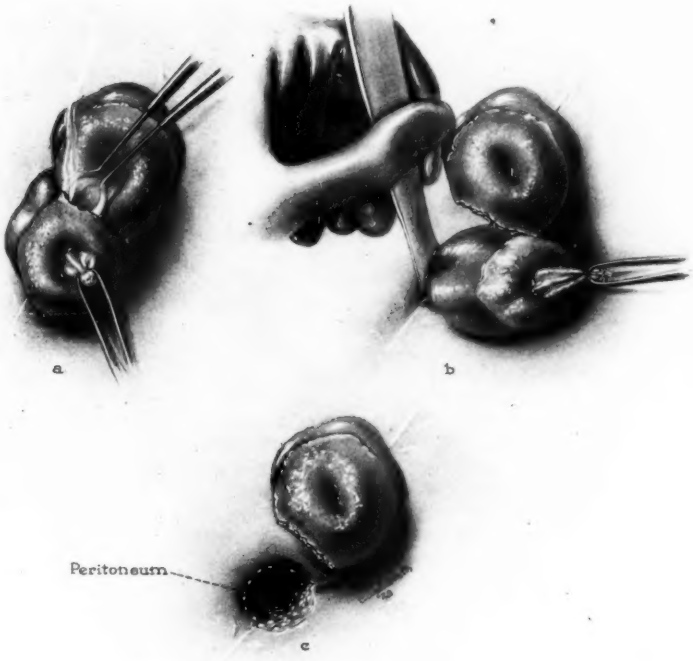

Fig. 16. a, Division of the mesentery and separation of the two loops of bowel with cautery. b, Blunt dissection with handle of knife separating lower segment which is to be removed from skin and underlying tissues. c, Appearance of wound from which lower loop was excised immediately after its removal.

hang *in situ* for about 10 days, when it is removed easily and simply by cautery. I believe that this step, while possibly making the operation a little more serious, may not be unwise since there is a question of the blowing out of the end and the producing of peritonitis (Fig. 16). This has been observed occasionally and apparently was a factor in the one death in my series of 26 cases.

RE-ESTABLISHMENT OF THE LUMEN OF THE BOWEL AFTER RESECTION

The question of re-establishment of the continuity of the bowel following resection is one which the surgeon is forced to decide in each case because of the almost universal insistence by the patient that the muscular mechanism controlling defæcation be preserved and the colostomy be abandoned subsequently. Occasionally a patient is so insistent that operation is refused unless this requirement be met, and if the growth is above the peritoneal fold and there is no lymphatic involvement perhaps one is justified in restoring the normal intestinal canal occasionally. As a working rule, unquestionably carcinoma at the rectosigmoid and below is best treated by colostomy high in the sigmoid and subsequent removal of the entire bowel or at least all except the anal canal below the stoma. Anatomical types influence this decision markedly, however, and no one standard operation is applicable to all cases in this group. Individualization occasionally will demand, after colostomy, re-establishment of the continuity of the intestinal tract. The important technical question in deciding this is the blood supply to the lower segment. After the inferior mesenteric vessels have been tied above the superior hæmorrhoidal branch, practically the whole blood supply to the lower segment and the rectum is sacrificed and yet studies of the collateral circulation and actual clinical experience bear out the observation that if a portion of the rectum is saved and the continuity re-established, if the blood supply to the upper segment is adequate, necrosis and sloughing will rarely result. In this

series of anterior resections, I re-established the continuity of the bowel in only one instance. The patient was the wife of a physician and both she and her husband insisted that this type of operation be carried out. Fortunately, there was no lymphatic involvement discovered at resection and it seemed not unwise to agree to their demand. The re-establishment is not difficult (despite the fact that the lower loop is deep in the pelvis) and may be accomplished quite accurately with two or even three layers of sutures with a good outlook for success. The fact that there is no tension on the suture line from the colostomy opening above and that any secretion in the segment may be removed by a rectal tube, is decidedly advantageous to healing and with the exception of infection which is outside the lumen of the bowel, there are few factors which prejudice success. As a general rule, however, this anastomosis should be deprecated, but unquestionably there are occasional exceptions favorable for its use.

EXCISION OF RECTAL STUMP AT THIRD STAGE

A further modification which has been employed several times in this series of cases is the removal of the blind pouch of rectum as a third stage to the operation. It is not certain whether this step might not be employed as a routine, the only argument against it being the long morbidity which in reality is not an argument in dealing with carcinoma. It makes the operation more radical and prolongs the convalescence, but it has been advantageous in the few instances in which I have done it. The first time it was necessary to remove the stump 7 days after the second operation. An abscess formed in the pelvis making drainage highly essential, and the easiest way to establish it seemed to be by excision of the rectal stump. This was done under sacral anæsthesia and was a simple procedure requiring only a few moments. Sutures were not used and the wound healed readily. Perhaps it would be an advantageous addition to the entire procedure, at a third stage, under local anæsthesia. There has been practically no trouble from this stump when it has been left *in situ*, and in only 2 instances in the 26 cases did it drain into the sinus established by the abdominal drainage tube. In both instances the drainage of mucus which followed irrigation of the rectum ceased without incidence.

ANÆSTHESIA

Spinal anæsthesia was employed as a routine in this series. Its advantages are so marked that its continuance is at least indicated in this type of operation. The freedom from pulmonary complications, the relaxation, and the lack of oozing at the time of operation, facilitate more satisfactory exposure and accurate technique.

SUMMARY

From March 30, 1927, to February 1, 1928, I performed 26 anterior resections of the rectosigmoid and upper rectum by the technique described, with one death. In this instance the patient was a man, aged 68, with an easily removable growth. He died on the fifteenth day after operation after having been out of bed for 2 days and without symptoms referable to the abdomen. His bowels were active, he was eating well and his progress seemed perfectly satisfactory until he was seized suddenly with symptoms of abdominal crisis and died 6 hours later. Necropsy disclosed plastic peritonitis which probably is present to a certain degree in practically all of such cases. There was no other satisfactory explanation for his death.

My experience with this series has been so satisfactory from the standpoint of the technique as well as operative mortality and morbidity that I am encouraged to continue this type of operation, either alone or with the modification suggested, namely, removal of the lower segment, either at the same stage or as a subsequent and separate maneuver. Certainly, it seems justifiable to hope for encouraging end-results in the light of the radical procedure made possible by the multiple-stage operation. The reduction of mortality is a striking example of what may be accomplished by co-operative measures in this group of cases, and the adequate rehabilitation measures combined with spinal anæsthesia and graded operation apparently encourage the prospect of a widespread removal of the growth and contiguous tissues with a lower death rate and a favorable outlook.

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FROM THE DIVISION OF SURGERY, JACKSON CLINIC

THYROIDECTOMY[1]

BY ARNOLD S. JACKSON, M.D., MADISON, WISCONSIN

NO single condition is responsible for the dangers and possible complications to be feared in performing thyroidectomy. A number of factors should be considered, such as the age of the patient, the duration of the disease, the extent of impairment of the cardiovascular-renal system, the condition of the patient, the kind of goiter, the skill and experience of the surgeon, and the choice of anæsthetic.

Until 1922, when Plummer suggested the use of iodine in connection with surgery in the treatment of exophthalmic goiter, postoperative hyperthyroidism was the most dreaded of all surgical complications. Frequently, in spite of weeks or months of preparation, and multiple stage operations performed with acumen and skill, the patient developed a high pulse rate and fever together with vomiting and delirium, and succumbed a few hours after operation. Since 1922, no deaths have occurred at the Jackson Clinic as a result of postoperative hyperthyroidism, in spite of the fact that only one ligation has been performed during the past 4 years. There have been a number of instances of severe reaction but in every case this condition has been controlled by the methods which I shall describe.

In exophthalmic goiter, the most fearful complication in my experience and probably in the experience of every surgeon interested in surgery of the thyroid is that of involvement of the recurrent laryngeal nerve. In some instances, the surgeon is probably not directly responsible because the mere stretching or compression of the nerve by œdematous or scar tissue may cause trouble. Since it has been determined that failure in the past to effect cure for this disease was due to the preservation of too much gland tissue, most surgeons are now advocating a more radical removal of the gland. Consequently there is greater danger of involving the nerve either by a hæmostat or suture unless "care is exercised to remain within the capsule." This expression has become almost stereotyped in descriptions of the operation for goiter and might perhaps well be discarded. In many cases of exophthalmic goiter, the gland is so friable and vascular and the capsule so thin that it is scarcely visible and the surgeon is fortunate to be able to resect the gland and control hæmorrhage. In adenomatous goiter there is frequently a tough fibrous capsule and the operation is a much simpler procedure.

Two of my patients were successfully operated on and were able to converse freely before leaving the operating room. A few minutes later they were reported to be cyanotic and dyspnœic. Unconsciousness quickly followed, but the condition was promptly relieved by removing the bandage and opening the wound, forcing the chin down on the chest and administering oxygen. Convalescence was uneventful, a secondary wound closure being made in 24 hours. Since laryngeal examination showed no involvement of the vocal cords, and the trachea was not collapsed, these near fatal complications have been attributed to sudden paralysis of the nerves from change of position and consequent severe tension.

If only one recurrent laryngeal nerve is injured the other will usually compensate, so that after a few days or weeks the voice is restored to normal. Even if bilateral adductor paralysis of the vocal cords occurs, tracheotomy may not be necessary, but if bilateral abductor paralysis occurs the increasing stridor, cyanosis, and dyspnœa necessitate this procedure. There should be no excuse for the occurrence of such a complication, yet there have been many instances in the past and with the increasing number of inexperienced surgeons performing the operation there will be more in the future. Too frequently this complication has been considered as tracheal collapse, a condition I have yet to observe.

Barring nerve injury, then, death should not occur following operation for exophthalmic goiter unless it is from tracheitis developing into pneumonia, or from hæmorrhage, or the more unusual complications, such as embolism, tetany, and tetanus. In spite of preservation of the tracheal fascia and of care in handling, fatal tracheitis may occur. Hæmorrhage, although it is frequently severe at the time of operation in the large friable vascular glands of long standing, is seldom dangerous, and usually is controlled by elevation and compression of the gland by the index finger. Injury to the lateral or jugular veins may prove more troublesome. Postoperative hæmorrhage is evidenced by restlessness, dyspnœa cyanosis, and increasing pulse rate. The diagnosis is made by examination of the neck which usually

[1] Submitted for publication December 23, 1927.

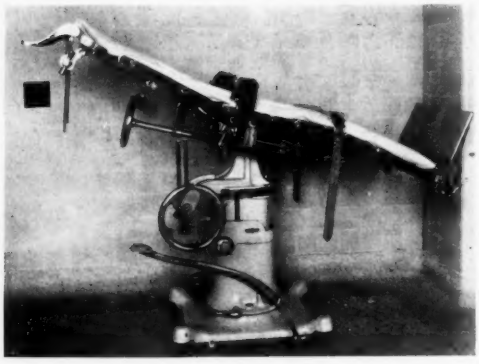

Fig. 1. Operating table with special head rest for goiter surgery.

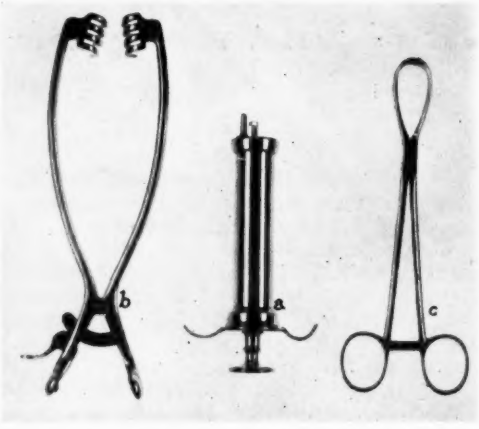

Fig. 2. Instruments used in goiter surgery: a, All-metal modified Meeker syringe. b, Self-retaining retractor. c, Grasping clamp.

has a full convex rather than a concave appearance.

Cardiac failure is seldom a serious complication in exophthalmic goiter except in cases of long standing. The condition of the heart can usually be regulated by iodine and digitalis. In toxic adenoma, however, chronic myocarditis is the most important condition to be considered, and cardiac failure is the complication to be most feared. However, when the disease is of short duration, the surgeon experienced, the anæsthesia local, and the pre-operative preparation correct, the patient obviously has an excellent chance for recovery and no complication should be feared.

PRE-OPERATIVE PREPARATION

The pre-operative preparation of patients in these cases depends on the kind of goiter and the condition of the patient. In non-toxic adenomatous goiter no preliminary treatment is required other than to determine that no contra-indications to operation exist, such as diabetes and tonsillitis. However, since extremely large adenomatous goiter is frequently substernal or intrathoracic and consequently exerts considerable back pressure on the heart, it may be advisable to give the patient several days' rest in bed and to give digitalis.

In toxic adenoma it is a different story. At the present time there exists a greater divergence of opinion regarding the preparation of these patients for operation, than at any time in the past. It makes little difference what method is used as even in the most skilled hands there is a definite mortality of from 1 to 5 per cent. The care of these patients is the most serious problem confronting the surgeon who is especially interested in goiter surgery. Until about 2 years ago, Plummer advocated the routine digitalizing of these patients. Then he stopped the use of digitalis and stated that a considerable lowering of the mortality had resulted. Some have felt that actual clinical experience warranted the continuation of the use of digitalis. Among the institutions supporting this view are the Cleveland Clinic, Lahey Clinic, Henry Ford Hospital, University of Michigan, and the Jackson Clinic.

During the past year, four deaths have occurred following operation for goiter in our Clinic. Two of these patients had toxic adenoma of long standing in which serious damage to the cardiovascular-renal systems had occurred. I have often wondered whether, if digitalis had not been given, these patients would have survived. Likewise I have wondered whether some of the other patients who presented equally poor risk would have survived if digitalis had not been used.

There also exists great difference of opinion regarding the use of iodine in these cases. Crile, Graham, and others, who support the view that exophthalmic goiter and toxic adenoma are one and the same, give iodine. In my own experience I have not found iodine beneficial in cases of uncomplicated toxic adenoma. I believe that seeming success has been due to the fact that in one of every four cases of exophthalmic goiter, adenomatous nodules may be found. In other words, a patient may have adenomatous goiter of many years' duration that has never become toxic. A few months before he consults his physician, exophthalmic goiter is superimposed. Iodine is

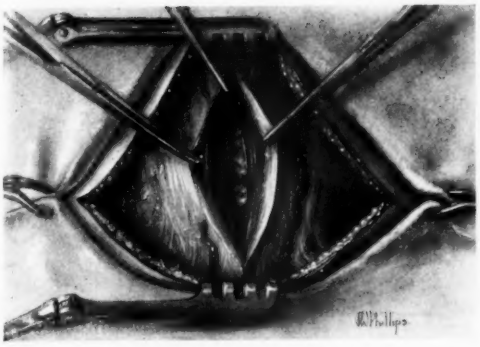

Fig. 3. Median incision through the fascia and muscles to the gland.

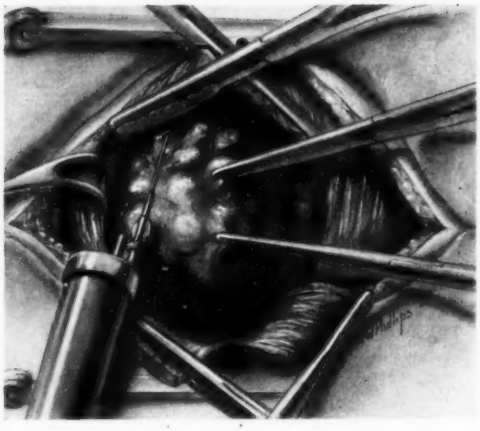

Fig. 4. Injection of novocain into the superior pole after the muscles have been divided and the gland is exposed.

given, supposedly for toxic adenoma, and there is immediate improvement. This error will continue to be made until the clinical differential points between exophthalmic goiter and toxic adenoma are clearly understood. Rest in bed, a high caloric diet, sedatives, and general symptomatic treatment are indicated. No patient should be allowed to become bedridden, but after a few days' absolute rest should be encouraged to walk around and build up for the operation.

The use of iodine has revolutionized the preoperative preparation of patients with exophthalmic goiter. Four years ago I gave up ligation and stage operation and whenever possible allowed the patient to prepare for operation at home. This is not so successful as preparation in the hospital since the conditions are necessarily not identical, but it is a great financial help to the patient. Many patients, of course, must be hospitalized and even kept in bed for several days, if there is cardiac decompensation or gastro-intestinal crisis. The old idea of keeping these patients in bed for weeks is wrong. No matter in what condition my patients come I never permit more than a week's rest in bed. Ninety per cent of them are operated upon within 10 days from the time they are

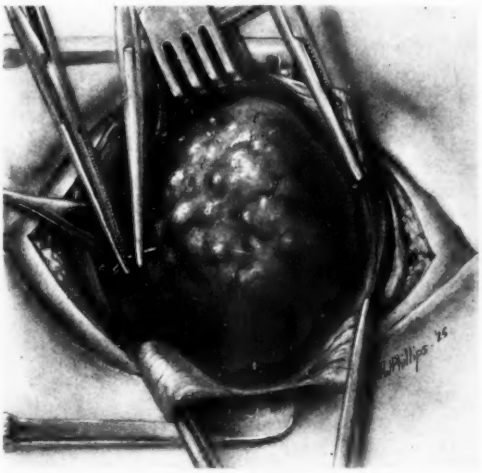

Fig. 5. Separate ligation and division of lateral veins (one of the most important steps of the operation).

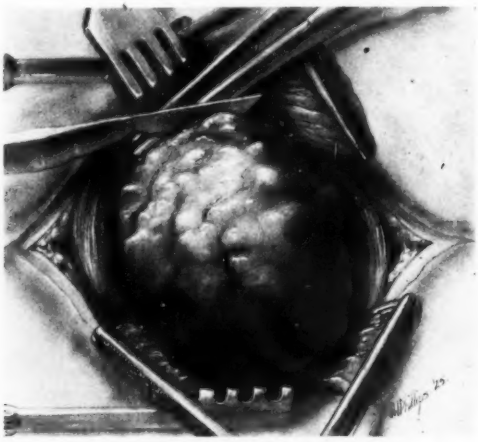

Fig. 6. Double-clamping of the superior thyroid vessels and division of pole, allowing easy mobilization of the gland.

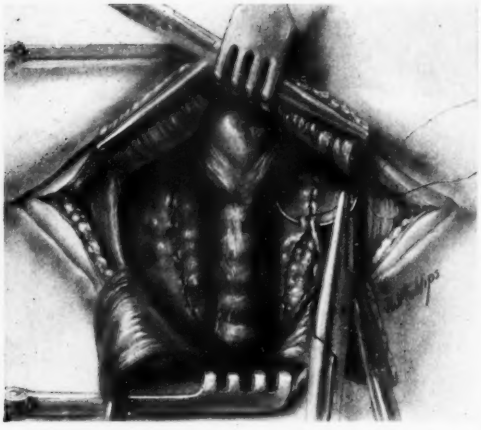

Fig. 7. Closure of capsule by interrupted or continuous suture after gland has been resected.

admitted. In 1923, I showed that the average drop in the basal metabolic rate within this time was 20 points, provided large doses of iodine were administered. I have always maintained that more satisfactory results could be obtained in a shorter time by saturating the gland with iodine than by merely using 15 drops a day. In the average case 60 drops a day is given, but two or three times this amount may be used for patients admitted in crisis. All my patients receive a high caloric diet (about 4,000 calories a day). Only the use of coffee and tea is restricted. They may eat all the beefsteak, all the cake and candy they will, and in fact anything they desire, so long as they eat.

Patients are routinely given 30 drops of the tincture of digitalis three times daily for 3 days. A half grain of phenobarbital is given three times daily. These drugs are not essential but are a matter of individual choice.

Next to iodine therapy, I believe that the psychologic factor is most important in handling these patients. I never operate unless the patient fully understands his condition and knows the time and reason for operation. He gains confidence by talking with others who have undergone operation. Crile employs another form of psychology, that of stealing the gland. Both methods apparently yield equally good results, but it should be understood that these patients cannot be handled by ordinary methods. It is the little things that make the big things in goiter surgery.

It is a mistake to starve these patients on the morning of operation. If iodine and food are withheld for several hours before operation, it is

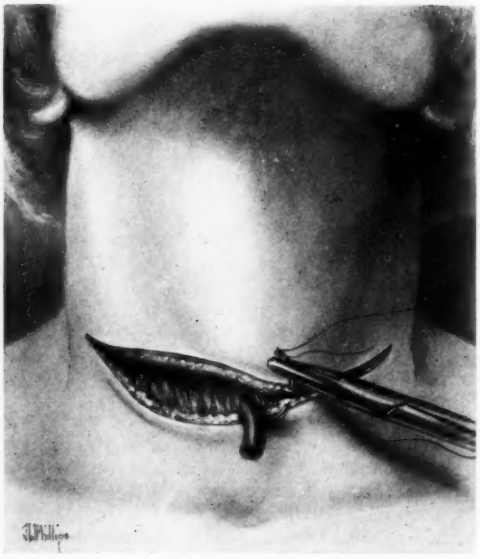

Fig. 8. Closure of wound by interrupted sutures in the platysma myoides and fascia.

only natural to suppose that the metabolism will be greatly increased, that the postoperative reaction will be severe, and that acidosis may occur. Our patients receive 200 grams of glucose with orange juice, as is given to diabetic patients, an hour before operation, and iodine is administered continually.

THE OPERATION

When the patient's condition has been judged fit for operation, he is so informed and perhaps is given an additional sedative on the night preceding operation. An hour before operation, ¼ grain morphine is given hypodermically and 15 minutes later 1/300 grain of scopolamine. The room is darkened and no relatives are permitted to come in. The patient's eyes are bandaged, vaselined cotton is inserted in the ears, and he is encouraged to sleep. When he is brought to the operating room, 1/6 grain of morphine is given hypodermically. This usually insures perfect anæsthesia when combined with novocain.

The position of the patient on the operating table is of considerable importance. I recently devised a table that I feel gives the best exposure of the operating field and at the same time assures the maximal amount of comfort for the patient (Fig. 1). The preparation of the skin is a matter of individual choice and it makes no difference

whether iodine, picric acid, or mercurochrome is used. Opinion is about equally divided regarding the anæsthetic; some surgeons prefer nitrous oxide, others ethylene, and still others novocain. In my experience, the latter following hypodermic injections of morphine and scopolamine has given excellent results; in fully 98 per cent of my cases this method has been used. The advantages are that the surgeon has the patient under his control; the patient can be made to talk and to cough; the possibility of injury to the recurrent laryngeal nerve is consequently lessened; the danger of postoperative pneumonia is almost eliminated, and in the case of removal of large substernal goiter, dyspnœa is better controlled. The disadvantages are that, if the patient is extremely apprehensive, the operation is more taxing both on the patient and the surgeon. In my experience non-toxic patients are frequently more nervous than the extremely toxic patients. Postoperative vomiting and reaction are materially reduced by the use of local anæsthesia. The infiltration method is preferable to nerve block because it is simpler and more speedy. One-half of 1 per cent of novocain with no adrenalin is satisfactory. An all-metal modified Meeker syringe that I have devised has proved helpful (Fig. 2, *A*).

In thyroid surgery, perhaps more than in any other, teamwork is essential and the service of two skilled assistants is desirable. Likewise the surgical nurse should be unusually keen and alert, since accuracy and intelligent co-operation may play an important part in the success of the operation. There is no talking during the operation and quiet is secured by covering metal surfaces in the operating room with rubber.

The instruments required for the usual goiter operation are: several dozen Kocher (large or small), Crile, or Lahey hæmostats, as preferred; one dozen small curved clamps; a grasping clamp (Fig. 2, *C*); sharp and dull retractors; a self-retaining retractor; four muscle clamps; two needle holders; one dozen towel clips, and four sharp scalpels.

When the incision is made, the scalpel must be carried at right angles to the skin the entire distance; otherwise the upper flap will override. The incision should, if possible, be made in a fold of the neck and should be fully an inch higher than is ultimately desired for the scar. The length of the incision will depend on the size, and consequently the type, of goiter. It should be slightly curved and its lowest median point should be at least an inch above the suprasternal notch. (Some surgeons prefer to outline it first with a colored solution or the back of the knife.) The incision should be made with a free clean sweep and made at once through the skin, the platysma myoides, and to the superficial facial layer. The flaps are then dissected free to give adequate exposure, and the superficial bleeding points are ligated. Among the various types of self-retaining retractor to hold the flaps in place is one which I have devised for this purpose (Fig. 2, *B*). A split towel protects the wound. Occasionally it may be advisable to ligate separately the external jugular veins. A median, or slightly lateral, incision is then made through the cervical fascia and underlying muscles, to the thyroid gland. The sternohyoid and sternothyroid muscles are next elevated from the capsule of the gland by blunt dissection. Whether or not these muscles are to be divided is a matter of individual choice. In many cases, I prefer to divide them as I feel that the greatly improved exposure more than compensates for the time lost. Haste is less essential than is a careful resection of the gland. If the goiter is large or friable and vascular there is danger of injury to the nerves or parathyroids, if there is inadequate exposure. In many instances it may be necessary to divide the muscles on but one side. Novocain should be injected into the muscles before they are divided.

When the gland is exposed it should be injected and then elevated. At the same time the capsule should be separated by either blunt or sharp dissection. Care should be exercised to avoid tearing the lateral veins and these should be separately ligated. The gland having been freed from its bed, the upper pole is exposed and the superior thyroid vessels located. These are double-clamped and then divided. Whether or not the vessels are secured by means of an aneurism or a regular needle is immaterial, and whether plain catgut or silk is used is merely a matter of choice. The important point is to ligate the vessels securely so that they cannot retract and cause hæmorrhage. When the upper pole has been divided the gland is easily mobilized. Some surgeons now prefer to free the gland from the trachea, a procedure that should always be carried out in case of large substernal goiter; others prefer to proceed by placing hæmostats laterally on the gland after the method of Halsted. It is a safe plan to leave some gland tissue below the clamp at the lower pole. The gland is then resected, the assistant clamping the vessels as they are about to be divided. The amount of tissue to be preserved depends on the type of goiter; a much smaller portion is preserved in the exophthalmic type than in the others. Next the vessels are ligated and a few interrupted sutures may be used to control the hæmorrhage. If the isthmus has not already been resected, this

is now done and the same procedure carried out with the left lobe. The tracheal fascia should be preserved intact since its removal leads to distressing tracheitis.

After the gland has been resected, the patient is asked to cough and strain so that any possible bleeding points may not be overlooked. If the wound is dry, the divided muscles may be approximated. In uniting these muscles in the median line, interrupted sutures and separate closure for the fascia are preferred (Figs. 3 to 7).

There is considerable difference of opinion regarding the question of drainage. I am convinced from the experience of others and from observation that some kind of drain should be inserted because of the danger of infection and of mediastinitis. Some surgeons prefer lateral to median-line drainage; some prefer rubber tubes, and others gutta-percha. Some, likewise, advocate silk in skin closure, others dermal, and still others clips. I have tried all methods of drainage and skin closure and have no particular preference. Apparently an interrupted closure of the platysma myoides and of the skin gives better results (Fig. 8). Too much care cannot be exercised in an effort to produce a perfect scar. The type of dressing used is immaterial as long as it is comfortable and sufficient to protect the wound and prevent soiling from drainage.

It seems almost unnecessary to say that the tissues should be handled with the greatest gentleness, since thyroidectomy cannot be successfully performed under local anæsthesia unless this surgical principle is observed.

POSTOPERATIVE CARE

The patient should be placed in bed in a semi-upright position and made comfortable with plenty of pillows. Tap water is given routinely by proctoclysis; in case of exophthalmic goiter, 10 drops of Lugol's solution is added to each 500 cubic centimeters of tap water. In these cases it is essential that sufficient iodine be administered both by mouth and by rectum to control the postoperative reaction. During a period of 6 hours before and after operation my patients receive 100 drops or more of iodine, well diluted. The amount given thereafter depends on the severity of the disease and the severity of reaction. Vomiting, tachycardia, fever, and restlessness may all be present, but, when they are exaggerated, a severe reaction is indicated. The proper preoperative preparation and the use of iodine will control all these symptoms.

Toxic adenoma offers a more difficult problem. The operation may have been performed speedily and with little apparent disturbance to the patient. The latter returns to the room seemingly in good condition. The next day the pulse rate may be irregular, the patient's mind rather cloudy, and in spite of all efforts to the contrary, another day may see the fatal termination of the case.

It does not seem necessary to say that the intake and output of fluid should be carefully observed; that in case of tracheitis a steam tent should be placed around the patient, and that excessive mucus may be controlled by administration of codein and small doses of atropin together with digitalis hypodermically. Phenobarbital and codein will usually control nervousness; if this fails morphine may be given.

POSTOPERATIVE COMPLICATIONS

Since the most frequent postoperative complications have already been discussed, it is necessary to mention only the treatment of these conditions.

Injury to recurrent laryngeal nerves. If one recurrent laryngeal nerve has been injured, temporary loss of voice usually occurs. More distressing are the dyspnœa and mucus. Codein, atropin, and steam inhalations of benzoin are helpful. If both nerves are damaged so that bilateral abductor paralysis of the vocal cords occurs, it will probably be necessary to perform tracheotomy.

Hæmorrhage. As soon as hæmorrhage is suspected, the patient should be returned to the operating room, if time permits. There the wound may be opened under ideal conditions, the blood clot removed, and possibly the bleeding vessel ligated. If the vessel cannot be readily located without risk of injury to the nerves, the wound should be packed and left open for secondary closure.

Every interne and nurse coming in contact with goiter patients should be familiar with the signs of postoperative hæmorrhage, since prompt action may save a life. Dyspnœa may develop so rapidly that it is necessary to remove the bandage and open the wound with whatever is at hand. Prompt action and the administration of oxygen are indicated.

Tetany. Postoperative tetany is an unfortunate complication especially if it is the chronic type. I recently made a study of this subject and reported several cases (2) in the hope that it might stimulate an interest in this problem and possibly lead to more satisfactory methods of treatment. It is evident that the radical type of thyroidectomy necessary to obtain cure and prevent recurrence

has resulted in an increased incidence of postoperative tetany. Practically every surgeon that has performed a considerable number of thyroidectomies has encountered this complication, and yet considering the enormous amount of literature on goiter, this subject has received but slight attention. There seems to be an inclination not to discuss unsatisfactory results.

The onset of postoperative tetany may be acute or chronic. Headache, radiating pains down the extremities, chronic twitching, and stiffness in the hands and feet are early symptoms. The extremities tingle and become numb; the face becomes stiff and distorted; spasms develop in the hands and often in the feet. The hands may assume the typical contraction of the accoucheur's hand. The diagnosis may be confirmed by eliciting attack through pressure over the main nerve trunk of the forearm (Trousseau's sign), or by tapping the facial nerve and causing the muscles of the corner of the mouth to twitch (Chvostek's sign).

In my experience, calcium administered either orally or intravenously has proved entirely satisfactory in controlling the attacks of tetany in all but one patient. In this case Collip's parathormone injected intravenously proved most beneficial. In the five chronic cases which I reported neither of these remedies effected cure. However, one patient has shown remarkable improvement following ultraviolet light therapy, and I have been sufficiently encouraged to follow this lead.

Embolism. Fortunately, embolism is a rare complication in surgery of the thyroid. I know of two fatal cases of air-embolism, one following ligation and the other following thyroidectomy. It should be borne in mind that the veins of the thyroid do not readily collapse and that they are valveless and consequently air is quickly aspirated. All bleeding points should be securely ligated.

Pneumonia. If operation is done under local anæsthesia, pneumonia can be almost excluded as a complication, and now the advent of the oxygen chamber promises to reduce still further the dread of this complication.

Infection. The incidence of infection following thyroidectomy is considerably lower than in abdominal surgery. In fact, if proper drainage has been supplied, infection rarely occurs. I believe that the wound should be probed daily at the site of the drainage tract and the neck lightly massaged. If the neck appears indurated and firm, proper drainage is not being secured and moist warm dressings should be applied at frequent intervals. If pus appears, healing is naturally delayed and a disfiguring scar may result.

PROGNOSIS

If sufficient tissue has been removed, a recurrence may be expected in not more than 2 per cent of cases of adenomatous goiter. This factor is dependent on age; the younger the patient the greater the possibility of recurrence. Usually, solitary cystic adenoma will enlarge and, if detected early, may be removed through a small incision. Adenomata in the region of the isthmus, beneath the mandible, or behind the trachea are frequently overlooked and are the cause of recurrence. Naturally, when only lobectomy has been performed, there is a strong possibility that recurrence will result. Some surgeons have stated that in resecting the gland it is necessary to remove all adenomata. I consider this impossible unless complete thyroidectomy is attempted, since in many instances the entire gland appears to be made up of minute adenomata.

A higher incidence of recurrence may be expected in exophthalmic goiter. In 1920, I assisted Judd in reviewing the postoperative results in two selected groups of patients operated on for goiter at the Mayo Clinic. It was possible to trace 90 of 100 patients who had been operated on for exophthalmic goiter; 66 per cent of these were free from all signs of the disease 6 years after operation; 13.3 per cent were markedly improved, and 5.5 per cent were slightly improved. Eleven of the patients died after leaving the Clinic. These operations were all performed before Lugol's solution was being used and on account of greater risk it was not always possible to remove as much tissue as can now be done. Recently I made a study of 300 cases of patients with exophthalmic goiter on whom I had operated and although the time elapsed is too short to pronounce cure, in only one case did the patient state that no improvement had resulted. In 95 per cent they reported that they were cured or greatly benefited; the remainder stated that their condition was improved. A number of these cures resulted only after a second thyroidectomy, the primary operation having been performed either by other surgeons or by myself. This should be encouraging for the surgeon and should refute the claims that exophthalmic goiter cannot be cured by thyroidectomy. In my opinion, however, cure does not mean operation alone, but includes a careful post-operative regimen for a year or more.

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DERANGEMENTS OF THE KNEE JOINT WITH SPECIAL REFERENCE TO THE RÔLE OF THE INTERNAL ALAR LIGAMENT IN TEARS OF INTERNAL SEMILUNAR CARTILAGES

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ALTHOUGH there is quite an extensive literature dealing with internal derangements of the knee joint, the subject is always of interest to surgeons not only because these derangements are constantly met in industrial surgery, demanding correct recognition and treatment, but also because the newer phases and different aspects from which derangements of the knee joint can be viewed are matters that are open to considerable discussion.

Derangements of the knee joint were recognized long before the era of the roentgen ray. As early as 1773, William Bromfield described the existence of cartilaginous bodies in the knee, and William Hay and John Hunter were also early contributors to this field of pathology.

The roentgen ray has not been of very great service in adding to our knowledge of internal derangements of the knee joint. The roentgenogram is of value only when gross bony or dense cartilaginous changes exist; but for investigation of displacements of the semilunar cartilages, and in derangements which are brought about by changes in the supporting ligamentous structures and the synovial membrane, the roentgen rays actually offer but very limited assistance.

Study of the knee joint has been carried out by most investigators on preserved limbs. The operating room offers but little opportunity for exact study of the tissues *intra vitam*, since, in knee-joint surgery it is imperative to avoid all unnecessary manipulations. Therefore, in order to study the structures and tissues in a condition approximating those in the living subject, it is necessary to carry out the anatomical investigations in the cadaver before post-mortem changes have taken place.

For the foregoing reasons and in order to obtain reliable data, 20 knee joints were studied soon after death. An attempt was made to simulate the various traumatic derangements and to visualize the mechanical effects upon the joint. It is only through a proper understanding of the anatomical structures of the knee joint, their relation to one another, and the pathology considered in the light of a careful clinical history, that a diagnosis of a torn cartilage can be established.

ANATOMICAL CONSIDERATIONS

In proportion to its size the knee joint is the most loosely constructed of all the joints. This applies to its bony architecture. The parts of the articulation which are apposed to one another are the spine of the tibia and the intercondylar notch, held together by the crucial ligaments. The articulation, when deprived of its supportive or binding structures, becomes unstable in every position and depends, therefore, for its stability and integrity upon the ligaments and muscles which bind it. The articular surfaces of the tibia and femur do not come in contact over a large area in any position; and in full extension a considerable space is created on either side of the joint on account of convex surfaces of the femoral articulations. These spaces are filled in by the semilunar cartilages, 2 crescentic disks, broad on their external surface and tapering internally, decreasing in thickness so as to form a wedge. The semilunar cartilages stabilize the knee when it assumes the extended position, and so prevent it from bending laterally. This stability is reinforced by the lateral ligaments—the internal lateral ligament aiding the external semilunar cartilage, and the external lateral ligament aiding the internal cartilage. The semilunar cartilages, as the name implies, are semicircular remains of a complete interarticular fibrocartilaginous disk with its center worn through (Whitlocke), so there are left sharp, free edges directed toward the center of the joint. The peripheries are thick and are attached on their external surfaces to the capsule. Both lose the cartilaginous character at their extremities and become fibrous. It is at this fibrocartilaginous junction that fractures or tears usually occur. The attachments of the semilunar cartilages are important from the traumatic standpoint. The internal cartilage is attached in front by the coronary ligament, a modification of the capsule, to the non-articular surface of the tibia immediately in front of the tibial attachment of the anterior crucial ligament, and in addition by the transverse ligament to its fellow on the opposite side. Bristow calls attention to the difference in length of the two coronary ligaments and believes that the frequency of displacement of the internal cartilage is due to the immobility of that cartilage as a result of its more firm fixation by the

coronary ligament. The external coronary ligament is 10 millimeters in length, while the internal is 6 millimeters in length. This suggests to Bristow that the external cartilage is allowed more mobility than the internal, and is possibly a factor concerned in the relative infrequency of damage to this meniscus. The security of the anterior cornu of the internal semilunar cartilage is often exaggerated, since that particular portion of the cartilage is more or less free.

The external surface of the internal semilunar cartilage is firmly fixed to the inner portion of the internal lateral ligament and also throughout its external border to the capsule. This area of fixation appears to be the point of contention to many observers, and is held responsible or at least as a contributing factor in the injury of that cartilage. Tenny, Sir Robert Jones, Henderson, Fisher, and others are firm in this belief. The fact that the internal semilunar cartilage has two fixed points, one posterior, the other lateral, and that the anterior horn is more or less insecure, contributes in a measure to its liability to injury.

The semilunar cartilages move with the tibia in flexion, and to a slight extent with the femur in rotation of the knee. That this movement occurs at the end of extension and in extreme flexion is an important fact in connection with the adjustment of a displaced cartilage and will be referred to later. Surls and Osgood give a splendid explanation of the movements of the semilunar cartilages. The semilunar cartilages are arranged so that they slide centrally when the joint is flexed, and peripherally when it is extended, so that the articulating surfaces are kept in contact at all times and a stable joint is maintained. All four extremities of these cartilages are attached firmly near the middle line of the joint. The portions between these extremities are attached to the joint capsule. Thus, there is a constant pull inward on the part of the attached extremities and an outward pull by the intervening capsule. But the pull inward is the stronger, and so the cartilages are held in apposition with the femoral articular surfaces. When the quadriceps contract, the joint extends and at the same time the capsule is drawn tense. The capsule transmits this pull to the semilunar cartilages and draws them out of harm as the joint is extended.

The external lateral ligament is a thin fibrous band stretching from the outer surface of the external condyle of the femur immediately above the popliteal groove, splitting the biceps tendon to become inserted into the head of the fibula. It is separated from the external semilunar cartilage by the popliteus muscle, which passes between it and the cartilage from in front backward. This muscle adds considerable support to the external lateral ligament. The tendon of the popliteus muscle is surrounded by a synovial sheath, and in its course sweeps past the outer surface of the external semilunar cartilage, just behind its center, producing a well-defined groove in the cartilage. At this point, the cartilage is therefore covered by synovial membrane. This is the only portion of either cartilage that has this arrangement (Fisher).

At this point, so-called ganglionic cysts of the semilunar cartilage develop. Phemister described such cysts and reported 2 cases. He cites Ollerenshawe, who found that an endothelial lining was present in some of the cyst cavities and concludes that these cysts might arise from misplaced endothelial elements that form the joint lining.

Figure 1 shows the external lateral ligament and its relations to the popliteus muscle as it passes behind it. The point of contact is the location for so-called ganglionic cysts.

The internal lateral ligament is a wide fan-shaped, fibrous band extending from the external condyle of the femur to the outer tuberosity of the tibia. It consists of a long anterior and a short posterior portion. The broad posterior portion is distinctly fixed to the internal semilunar cartilage. This fixation is a definite disadvantage since in a sudden twisting of the joint, the cartilage cannot get out of the way of the articulation and becomes jammed and torn. The internal semilunar cartilage is, therefore, more commonly injured than is the external, the percentage being about 12 to 1. Sir Robert Jones gives the percentage as 7 to 1. A strain upon the internal lateral ligament is much more severe when it is associated with a twisting movement of the joint.

In order to bring about lateral movement of the knee joint, we found it necessary in our experiments to sever not only the internal lateral ligament, but also the crucial ligaments.

Figure 2 shows the relation of the internal lateral ligament to the internal semilunar cartilage. Note the portion that is free and retracted by the instrument. The illustration also shows the transverse ligament which binds the 2 cornua of the semilunar cartilages. The fixation of the anterior cornu of the external semilunar to the tibial articulation is quite firm.

The crucial ligaments are situated in the center of the articulation and have a very important function. The anterior crucial ligament prevents the tibia from slipping forward upon the femur, while the posterior crucial ligament prevents the tibia from sliding backward upon the femur. The

crucial ligaments assist the lateral ligament in maintaining stability of the joint when it is in the extended position. When an individual has received an injury to the knee joint and the examiner is able to displace the tibia forward or backward upon the femur, the knee being in the extended position, the finding suggests a rupture of the crucial ligaments.

CASE 1. J. F., female, entered the Michael Reese Hospital with a congenital dislocation of both hips and knees. By the closed method, the hips were successfully reduced, but the knees were not. There was a subluxation of the tibia backward upon the femoral condyles. An open operation was attempted and an arthrotomy performed. The posterior crucial ligament was short and did not permit a reduction of the tibia, while the anterior crucial ligament was very much increased in length. It lay in the center of the articulation like a tendinous band. The posterior crucial ligament was cut, thus permitting the tibia to come forward; the anterior crucial was divided and about one-half an inch was resected; the ends were brought together; and the knee was placed in extension.

This case demonstrated the inability of sliding the tibia forward on the femur because of the short posterior crucial, and the retention of the tibia in its normal relation to the articular surface of the femur by shortening the anterior crucial ligament. It must be noted, however, that when luxation of the tibia backward on the femur occurs and remains so for a period of time, the posterior capsule contracts, making induction impossible. This also takes place when the knee remains in flexion contraction for a long time and extension becomes limited.

CASE 2. S. H., female, about 26 years of age, was brought to the hospital with the history that she was in an automobile accident and sustained an injury to the left knee joint. She stated that her outstretched knee was struck forcibly when another occupant in the car was thrown against her. On examination the knee joint was found swollen and very painful; there was considerable fluid present; there was considerable lateral mobility, and the tibia could easily be displaced forward on the femur. A roentgenogram revealed a fracture of the inner articular surface of the tibia extending through the tibial spine. A diagnosis of tear of the crucial ligaments together with a rupture of the internal lateral ligament was confirmed.

The synovial membrane of the joint is an endothelial serous lining which surrounds all of the structures of the joint, adapting itself to prominences and depressions. The joint is divided into two main compartments, the small posterior and the larger anterior. The synovial membrane extends for about 1½ inches above the superior border of the patella. The synovial sac is filled with an inflammatory exudate, all of the normal superficial outlines of the joint are obliterated. This is especially true of the suprapatellar surface as well as the lateral surfaces of the joint above the patella.

In the infrapatellar space a fold or pad can be seen stretching across the joint and filling the space between tibial and femoral articulation. This fat pad is triangular in outline with the base directed upward and forward, its apex is directed to the center of the joint, and it is held in position by a well-defined ligament known as the ligamentum mucosum. This extends from the apex upward and backward to the intercondyloid notch, in front of and blending with the anterior crucial ligament. Laterally the pad blends with the capsule, and in addition is supported or suspended by 2 fibro-elastic bands called the alar ligaments. These bands are found on its lateral peripheral borders. They extend upward and adapt themselves to the outer and under borders of the patella, blending with the aponeurosis of the quadriceps extensor tendon. The outer alar ligament is very indistinct and often missing; and although frequently it can be definitely made out on the outer under peripheral border of the patella, its lower extremity becomes indistinct and blends with the pad fat. The inner alar ligament is constantly present and often forms a double fold, especially in males and in well developed knee joints, but in atrophic knees, it participates in the atrophy of the other structures. The inner alar ligament, as a rule, is wider than the external and can be traced through the fat pad, sending fibers which blend with it and descend to become incorporated or inserted with the coronary and transverse ligament into the anterior cornu of the internal semilunar cartilage. When traction is produced upon the internal alar ligament, the pad can be elevated, and the cornu of the semilunar cartilage can in turn be displaced from its position.

Figure 3 shows the infrapatellar fat pad. The band of fibrous tissue, which holds the pad to the intercondylar notch, should be noted. This is the already mentioned ligamentum mucosum. The illustration also shows the folds which extend from the pad to the outer borders of the patella. These are the alar ligaments. The inner fold is very distinct and in this case is double. The fibrous bands from the internal alar ligament extend downward to become incorporated with the coronary ligament and attached to the anterior cornu of the internal semilunar cartilage.

I hold the opinion of Pozet that the internal alar ligament plays a definite rôle in the production of displacements and rupture of the internal semilunar cartilage. When the knee joint is opened so that the internal cartilage becomes visible and motion of the joint is carried out either

in flexion or extension, the cartilage cannot be misplaced from its position. However, when forcible traction is exercised upon the patella, the anterior cornu of the internal cartilage can be brought forward and away from its tibial position.

We can, therefore, visualize the position of the knee joint which favors injury to this cartilage, namely, slight flexion of the knee, abduction of the foot, and inward rotation of the femur. Should an emergency require a sudden rectification of the joint to its normal position, the following events should occur: sudden contraction of the quadriceps tendon, which pulls the patella with a violent jerk. The anterior cornu of the internal cartilage would then be pulled away from the region of safety by means of the internal alar ligament. In addition, the knee in trying to assume the erect position would have to pass through a rotary, or as it is often referred to, a "screw home" movement, accompanied by sudden extension. If the cartilage does not get out of the way of the articulation, it becomes pinched and torn. Pozet has traced distinct bundles from the fibrous folds already described to the anterior ends of the semilunar cartilages, and believes that they serve to pull the semilunar cartilage forward and upward with the contraction of the quadriceps. Tenny could not trace such bundles, but found these folds "spreading out generally into the fibrous framework of the infrapatellar pad." He believes that their function is to pull this pad forward and upward out of harm's way during extension. This statement may be correct, but it does not detract from the idea that is here presented, namely, the effect of the alar ligament upon the internal semilunar cartilage. Tenny asserts that these fibrous bands do not appear in joints hardened in formalin. It must, however, be remembered that Tenny did his work on cadavers so that these delicate structures may have become distorted. Hoffa states that the lower part of the fat pad joins the meniscus, and is also connected to the periosteum of the front part of the tibia. The connection to the periosteum alludes to the coronary ligament.

The infrapatellar fat pad gives off numerous small tail-like padules or fringes, which are intended as wipers of the articulating surfaces—so-called lubricants. When by inflammatory hyperplasia these tail-like padules become elongated, the alar ligaments cannot pull the fat pad up out of the crushing, grinding articulation and thus they often become pinched, and cause the characteristic symptoms of pain and locking. It must be remembered that derangements of the semilunar cartilages may be associated with other pathology. One, therefore, cannot emphasize too strongly the importance of a complete exploration of the knee when the clinical history and physical findings are not clearly definite. In several of our cases of ruptured semilunar cartilage, a small portion of the synovial membrane was removed. This tissue in every case showed a chronic inflammatory change. It must, therefore, be borne in mind that repeated locking of the joint is not only associated with a mechanical disturbance which disappears with the reduction of the cartilage, but often results in a chronic synovial inflammatory change which may persist even when the cartilage is removed.

CASE 3. A male patient, 55 years of age, came to the hospital stating that about 20 years before he had stumbled and sprained his knee joint. He felt quite sure that the joint locked at that time. He has had numerous lockings since then. A roentgenogram was taken of the knee and it disclosed numerous osteocartilaginous bodies. The joint was operated on. The anterior portion of the internal semilunar cartilage was practically gone, but there was a chronic synovitis with numerous fibrous bands stretching across the joint and a number of osteocartilaginous bodies.

MECHANISM OF RUPTURE OF THE INTERNAL LATERAL LIGAMENT AND RUPTURE OF THE SEMILUNAR CARTILAGE

The knee is a modified hinge-joint with only a slight degree of sliding and rotation, which takes place only in the final act of extension. The most insecure position of the joint is midway between flexion and extension, and is referred to by Morison as the danger zone. When the foot is firmly fixed upon the ground, the knee being slightly flexed, a sudden rotation of the femur inward with an attempted extension of the knee may cause a rupture of the internal cartilage. This can best be illustrated by citing some illustrative cases:

CASE 4. A dancer, during a performance when he was to catch his partner as she descended from mid-air, suddenly felt that his right foot was glued to the floor, as though he had stepped on some gum. He could not take the sliding step to break the impact of the heavy weight. His knee bent under him and he experienced a sharp stabbing pain. The knee joint became markedly swollen and was locked in a flexed position. An X-ray suggested a torn internal lateral ligament and a displacement of the cartilage. Reduction was accomplished by reposition.

CASE 5. A painter standing upon an insecure ladder swayed backward, while his foot was caught in a rung. In trying to regain his equilibrium he twisted his left knee joint and experienced a severe pain on the inner side of the knee. Effusion followed, the knee became locked, and the locking recurred on several occasions. The X-ray report was negative. When the knee joint was opened, the cartilage was found loosened and torn at its fibrocartilaginous junction.

CASE 6. A girl, age 25 years, stated that while she was riding in a crowded car and hanging on to a strap, the car came to a sudden stop and her body swayed forward while

her right foot remained firmly fixed to the floor. She experienced pain on the inner side of the right knee joint. She walked home but the pain in her knee continued. When she came for examination there was some effusion in her knee, a limitation to examination, and pain on the inner side of the knee below the patella. The internal semilunar cartilage was found attached.

CASE 7. The patient presented himself at Michael Reese Hospital with the following history: Several days previously, while shovelling coal from a wagon and throwing it to a considerable distance, he twisted his right knee and felt a sudden severe pain on the inner side of the knee, "causing the knee to give way from under him." He stopped work and limped home. When the knee was examined, it was found to be locked in semiflexion. There was a distinct limitation to extension, and some pain directed to the inner side of the knee immediately below and in front of the patella. X-ray examination revealed no changes in the joint and a diagnosis of a displaced and a torn cartilage was made and confirmed at operation. The cartilage was torn at its fibrocartilaginous junction.

In addition to the anatomical factors contributing to derangements of the semilunar cartilage, certain physiological reasons may perhaps explain their formation. Thus the normal rotation of the body in right handed individuals is toward the left. The body pivots upon the left knee in the act of rotation. The foot is arrested by the ground while the femur rotates inward upon the tibia. This is illustrated in the act of bowling, golfing, and shovelling, and may account for the fact that the condition occurs more commonly in the right knee joint.

DIAGNOSIS

The diagnosis of lateral ligament rupture and of fracture and displacement of the semilunar cartilages depends almost entirely upon the clinical history. These accidents occur as a rule in young, active adults and more frequently in men than in women. The sequence of events in the production of the accident must be carefully investigated. A twist and a sudden attempt at extension of the knee is the characteristic method of production of these derangements.

Because roentgenograms do not disclose derangements of the soft tissues, attempts have been made to introduce gaseous substances into the joint for the purpose of bringing out the soft-tissue structures. Kleinberg reported a series of cases in which the knees were injected with oxygen. We have inflated the knee joint with carbon dioxide for the same purpose. As it is an end-product of metabolism, we felt that its effect upon the tissues would not be as irritating as oxygen or nitrogen, and also that its absorption would be more rapid. Fifty knees were inflated and in each instance the practice was of great aid. When the clinical history is clear and one is certain about the findings, inflation should not be employed, but when one is in doubt as to the pathology, inflation is of great help.

Technique of inflation. The knee is prepared as for an arthrotomy. The knee is roentgenographed in the anterior posterior and lateral position. It is then flexed to an angle of about 90 degrees and a needle inserted on the inner side below the patella. The carbon dioxide is introduced until a soft crepitus can be felt over the joint. About 30 to 40 cubic centimeters of gas is sufficient. One must be sure that the needle enters the joint before the gas is permitted to flow, otherwise the gas enters the soft periarticular tissues. There is a momentary sensation of distention of the joint but no extreme pain nor discomfort. Most patients upon whom inflation of the knee was performed were from the out-patient department and were permitted to go home soon after the inflation.

The spaces to be studied are the suprapatellar pouch, the infrapatellar space, and the posterior compartment. The suprapatellar pouch assumes the appearance of an inverted gall bladder. The infrapatellar space is almost triangular in outline while the posterior space is crescentic. In a normal knee joint all the spaces are clear and well defined (Fig. 5). Changes in the infrapatellar space are indicative of hypertrophic villus synovitis, chronic synovitis, changes in the pad of fat, and displacements and tears of the semilunar cartilages (Fig.6).

The diagnostic signs and symptoms of a torn cartilage in order of their importance are: pain, locking, limitation to full extension, and effusion.

As a result of a mild torsion producing a tear and displacement of the internal semilunar cartilage, the knee becomes *locked;* this locking is accompanied by a sickening pain which persists for some time, and extension of the joint is more or less difficult. The pain as a rule is referred to the inner side of the knee immediately below and to the side of the patella. When numerous lockings occur, the pain is less intense. When reposition is accomplished, the pain at once subsides and the knee assumes a normal extension.

Limitation to full extension is the next important symptom after pain. Normally the knee joint can be extended to an angle approximately 180 degrees. In derangements due to semilunar cartilage displacement, the knee is bent and it is difficult and painful to straighten it out. When reposition of the cartilage is accomplished, the knee can be straightened to almost normal extension.

Pain is a constant symptom and is described as sharp, lancinating, stabbing, or boring in char-

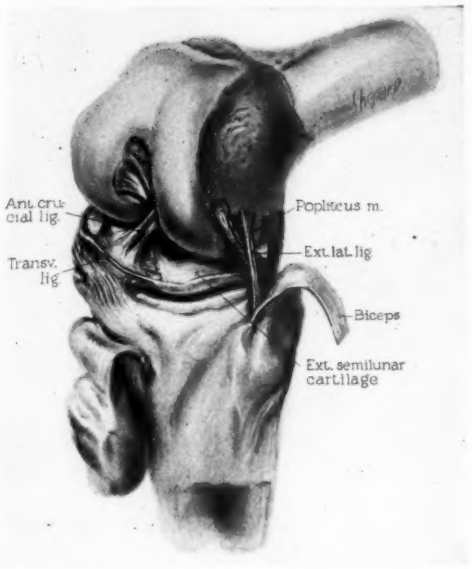

Fig. 1. External lateral ligament and relation to popliteus muscle.

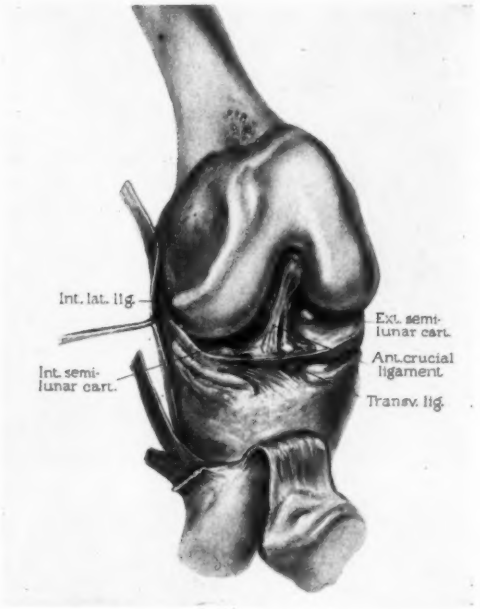

Fig. 2. Relation of internal lateral ligament to internal semilunar cartilage.

acter. The pain is referred to the inner side of the knee below and to the inner side of the patella. The pain is often severe enough to keep the patient awake and is most intense when motion of the joint is attempted. Tenderness on pressure is marked at the site of the cartilage and over the internal lateral ligament. Pain is also experienced when an attempt is made to stretch or mobilize the knee joint. When the cartilage is replaced the acute pain subsides, but there may remain a dull ache for a short time and pain may be experienced when the joint is moved.

Effusion is variable in quantity. As a rule there is very little fluid in the joint, but the knee may be increased in size. When the joint is locked in flexion and is permitted to remain in that condition for some time, the effusion is increased in amount. Repeated lockings may not cause further effusion.

Aspiration of the joint is never indicated. The effusion is a result of irritations and trauma, and is an exudative process. When effusion is present, inflation of the joint for diagnostic purposes should be postponed until it has cleared up.

CASE 8. A professional dancer, aged 32 years, entered Michael Reese Hospital with the following history: About 4 years ago she had slipped and twisted her knee while dancing. The knee was quite painful and she was unable to

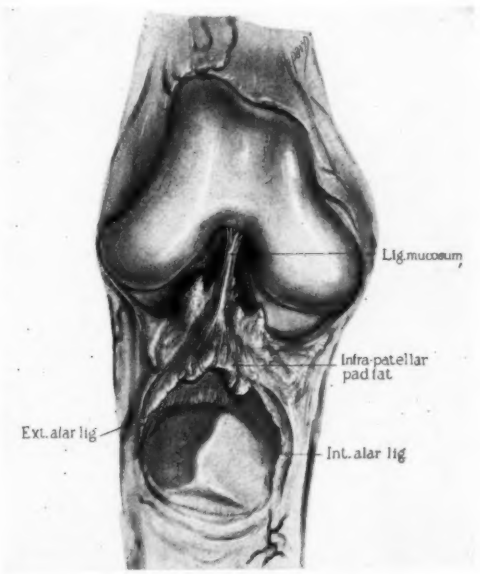

Fig. 3. The infrapatellar fat pad.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4. Anteroposterior view of an inflated knee joint. Inflation of the knee joint obtained by carbon dioxide as stated in the text. Note the following: both cartilages are plainly visible in the lateral recesses of the knee joint. The attachment of the internal lateral ligament to the internal semilunar cartilage is plainly visible. The external semilunar cartilage is seen unattached. The gas distends the suprapatellar pouch. This is a normal knee.

Fig. 5. Shows inflation of a normal knee joint by means of carbon dioxide. Note the following: the suprapatellar pouch assumes the shape of a gall bladder. The walls are smooth and regular. The infrapatellar space is more or less triangular in outline and the posterior compartment of the knee joint assumes a semilunar outline. When pathology is present in the knee joint, these spaces are distorted, increased in size, and show the presence of foreign material, either cartilaginous or soft tissue structure, as in Figure 6.

Fig. 6. Lateral view of an inflated knee joint showing a suprapatellar pouch, irregular in outline and somewhat diminished in size. The infrapatellar space is more or less slit-like in appearance. At the anterior articular surface of the tibia, corresponding to the position of the internal cartilage, a shadow is present. This reveals a displaced cartilage which was confirmed at operation. Associated with the displaced cartilage a chronic synovial change was present in the knee joint. This accounts for the decrease in size of the infrapatellar space and is probably due to a hypertrophied pad of fat.

straighten it. On the second day the knee was swollen and was in acute flexion. Hot applications were used and the patient remained in bed for about a week. The swelling subsided and the pain gradually disappeared. She resumed her dancing soon afterward. About a year ago she injured her right knee again and had a recurrence of symptoms similar to those she experienced after the first injury. She then came to the hospital. The diagnosis was made of a torn and displaced internal semilunar cartilage.

The knee was opened through a Jones incision and the anterior half of the cartilage lay like a free foreign body. This was removed and the knee joint closed. The knee returned to a normal state and the patient was free from trouble until the present time.

Several weeks ago she was reclining on a sofa. When she attempted to rise she slipped and fell to the floor, twisting her knee under her. She does not remember whether her foot touched the ground or not. She thinks that she fell on her flexed knee. There was extreme pain on the inner side of the knee. Slight swelling soon appeared and the pain was such as to prevent her from sleeping.

On October 7, 1926, a median arthrotomy was performed under anæsthesia. The whole interior of the joint was carefully and thoroughly inspected. The suprapatellar space was hyperæmic and congested, and presented a granular eyelid appearance. The fat tags were elongated, congested, and thickened. The fat pad was enlarged and participated in the general pathological picture of chronic synovitis.

The remaining internal semilunar cartilage was of the bucket-handle type of displacement. The anterior portion was gone and the remaining portion of the cartilage appeared smooth, sheared, and displaced to the interior of the joint. The cartilage was removed in its entirety together with the thickened synovial tissue and a portion of the fat pad. The patient regained free motion in the joint and left the hospital on the tenth day, walking out on crutches.

This case illustrates the importance of carefully inspecting the interior of the joint. If a careful examination of the internal cartilage had been made at the time of the first operation, there would have been no recurrence of the condition. However, it was thought at the time of the first operation that the anterior free margin had been torn off and that the remaining portion of the cartilage was in place.

CASE 9. A young, athletic man, 26 years of age, states that about a year and a half ago while at a party playing a game where he had to kneel on a pillow, he came down heavily on his right knee and then got up rather quickly. He felt a sudden pain in his right knee and could not straighten the joint to its normal extended position. The

knee hurt him considerably and for 10 days he limped. After that time he had occasional pain in the knee, localized on the inner side of the joint below the patella. During the attacks of pain his knee locked and he could hear a click in the joint.

On examination the knee appeared normal—no swelling or effusion. It could be extended and flexed to almost the normal range. On the inner side of the knee joint, the examiner's thumb being firmly held over the region of the internal cartilage, a click such as one often finds over a slipping tendon could be felt. There was some tenderness. X-ray examination was negative.

Diagnosis was made of a displaced and ruptured internal semilunar cartilage, and on September 7, 1926, the knee joint was operated on. The method employed in this case was the same as that carried out in all our cases and will be described in detail.

OPERATION

The extremity is shaved above and below the knee joint, special care being taken to remove all hair over the knee, since long hair may be responsible for infection following the operation. The knee is prepared the night before by a thorough washing—ether and alcohol, and a coat of iodine. This procedure is repeated at the time of the operation. One must always bear in mind that because infections do not occur as commonly after operation as in times past, one cannot become lax in the preparation of patients. I always prepare the knee joint myself in order to be absolutely sure of the asepsis. The knee is bent to an angle of 45 degrees over the foot of the table. An elliptical incision is made ½ inch to the inner side of the patella, beginning about 1½ inches above and carried about 1½ inches below the patella. All bleeding points are ligated to prevent any possibility of hæmorrhage under the skin. Very fine catgut is used and the ends cut very short. The parts are covered with wet lap sponges and a second knife used to cut the subcutaneous tissues and the fascia down to the capsule of the joint. The capsule appears like a tense, loose structure. This is incised with a pair of scissors and the edges are caught as in the case of the peritoneum in abdominal section. The edges are retracted and the incision is completed above and below, to expose the joint. The first visible structure is the inner condyle of the femur. Two small ribbon retractors are introduced into the joint and the joint is thoroughly inspected. The cartilage can now be easily seen resting on the articular surface of the tibia. The anterior crucial ligament appears as a firm, fibrous band. The anterior cornu of the cartilage is gently grasped with a tissue forceps, and inspected for pathology. In this particular instance the cartilage was long and twisted and displaced to the center of the joint. It was a typical "bucket-handle" variety. The cartilage was severed at its proximal portion close to the tibial attachment, and pulled forward and severed from the capsule by means of a curved dissecting scissors at its posterior attachment.

The fat pad can be examined for inflammatory changes and elongations of fat tags. In each instance, we found a change in the fat pad characterized by inflammatory hyperplasia. Any oozing that takes place can be checked by a small gauze pack which is inserted into the joint and held there for a few moments. It is not advisable to compress any small bleeding points nor is it advisable to place ligatures into the joint. If ligatures are to be used they should be of fine catgut and the ends cut very short. The capsule is now sutured with a fine catgut stitch, the subcutaneous tissue with No. 1 chromic catgut. The skin is closed with a running silk suture. No drains should ever be inserted into the knee. The limb is placed in extension in a posterior molded plaster splint. Passive exercises are to be employed as soon as the patient can bear them. On the tenth day, the patient is encouraged to use the limb and permitted to step with the aid of crutches.

As one gains experience in this type of surgery, he approaches the knee joint without apprehension. The employment of the Lane technique cannot be emphasized too strongly in connection with knee-joint surgery, and it must always be remembered that an infection following the removal of a semilunar cartilage can leave the patient with a stiff knee. When the diagnosis is uncertain, a median arthrotomy should be performed. The knee joint is approached through a split patella. In this way the entire knee joint may be inspected.

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TUBERCULOMA OF THE TRACHEA[1]

By PORTER P. VINSON, M.D., and HAROLD C. HABEIN, M.D., Rochester, Minnesota

TUBERCULOSIS of the trachea secondary to infection in the lungs is rarely diagnosed except at postmortem examinations when small superficial, recently formed, lenticular ulcers involving the posterior wall of the trachea are found. These ulcers are a terminal complication of pulmonary or generalized tuberculosis. Statistics vary as to the frequency of their occurrence. Heinze reports an incidence of 1.5 per cent. Ophüls reports infection in the trachea and bronchi in 10 per cent of all cases of active tuberculosis. Gidionsen, and Mackensie, and Schmiegelow report cases of primary tuberculosis of the trachea. Occasionally tuberculous tracheobronchial lymph nodes ulcerate through the wall of the trachea.

The case herewith reported is unusual because the patient's general health was extremely good and the only symptom was inspiratory dyspnœa. Observations also indicate the value of bronchoscopy when symptoms could easily have been mistaken for pulmonary fibrosis by ordinary examination.

A woman, aged 48 years, first registered at the Mayo Clinic on June 18, 1926. The patient's father had died from pulmonary infection, probably tuberculosis. One maternal aunt, one uncle, and two cousins had died from tuberculosis. She had had scarlet fever, pneumonia, and typhoid fever in youth. She complained chiefly of cough, which had been gradual in onset, starting approximately 12 years before her admission to the clinic, usually more pronounced during the winter and spring, and clearing up entirely in the summer. Five years previously the cough had been considerably worse and 1 year previously it had become more persistent and there had been a little sputum, occasionally blood-streaked. At times there was slight fever; 7 pounds in weight had been lost.

The patient weighed 110.5 pounds. She coughed frequently during examination. There was dullness in both apexes with persistent crepitant râles. The hæmoglobin was 75 per cent; erythrocytes numbered 4,650,000; and leucocytes, 8,900. The blood Wassermann test and the urinalysis were negative. Roentgenograms of the chest showed bilateral pulmonary tuberculosis with bronchiectasis at both bases. Tuberculosis bacilli were present in the sputum. A diagnosis of bilateral pulmonary tuberculosis was made and the patient was referred to a sanatorium for treatment. She spent the greater part of the following year in a sanatorium in Colorado and seemed to make a splendid recovery, gaining 20 pounds in weight.

In December, 1926, increasing inspiratory dyspnœa developed gradually and reached its maximal severity in March, 1927. Up to the time of the second admission to the clinic in June, 1927, there had been practically no change in the degree of dyspnœa. There was marked inspiratory dyspnœa. Cyanosis of the lips and finger tips was brought on by such exertion as walking across the floor. There had been a loss of 15 pounds in weight. The pulmonary condition appeared to be quiescent. There was no fever and the roentgenogram of the chest was interpreted as showing a healed lesion. Examination of the larynx was negative.

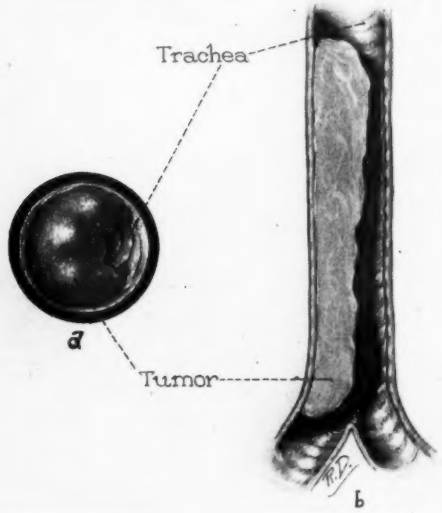

Fig. 1. *a*, Bronchoscopic view of tumor of trachea. *b*, Schematic drawing showing extent of tracheal tumor.

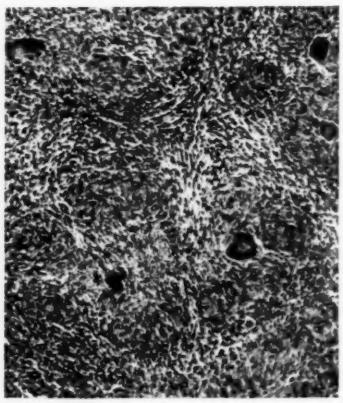

Fig. 2. Photomicrograph of tissue removed from tracheal tumor. (× 75.)

[1]Submitted for publication August 18, 1927.

At bronchoscopic examination, the left wall of the trachea was found to be invaded by a large mass which reduced the lumen to about one-fourth its normal size. The mass began about 2.5 centimeters below the larynx and extended almost to the tracheal bifurcation. It was difficult, however, to determine with accuracy the lower limits of the process. The tumor was granular and firm, and moderate bleeding followed the removal of a section for microscopic examination.

Grossly the lesion resembled a malignant tumor of the trachea but the extent of involvement was greater than had been previously noted in tracheal carcinoma (Fig. 1). The microscopic examination of the tissue disclosed its tuberculous nature (Fig. 2).

Following bronchoscopic examination the patient was able to breathe with greater comfort because on introducing the bronchoscope to the bifurcation of the trachea, superficial ulcerating tissue was removed and the lumen of the trachea was thereby enlarged. A course of treatment by deep roentgen rays was given and the patient instructed to continue with the usual antituberculosis regimen.

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FASCIAL GRAFT FOR DISLOCATION OF ACROMIOCLAVICULAR JOINT

BY STERLING BUNNELL, M.D., SAN FRANCISCO, CALIFORNIA

IN complete upward dislocation of the outer end of the clavicle, not only the acromioclavicular ligaments but also the conoid and trapezoid ligaments that should hold the clavicle down to the coracoid process are ruptured. This allows the outer end of the clavicle to ride upward in the shoulder when the patient lifts, produces considerable deformity, causes weakness in the lifting power of the arm and difficulty in some shoulder movements.

At operation not only should the acromion process and the clavicle be fastened together but the clavicle should also be held down to the coracoid process. Ankylosis of the joint will not permit movement. Wire, if used in tying the parts together, will wear and break, as in any movable part. Tying of the clavicle to the coracoid process with fish-line, has been recommended also, but such a foreign body will wear out in a short time.

Fascia is the ideal material, as it is a natural binding agent, it hypertrophies under conditions of normal tension, allows normal motion in joint, and lives as long as patient. A quick, easy, efficient method of using fascia has been devised.

Through an L-shaped incision with its apex an inch anterolateral to the joint, the upper surfaces of the acromion and clavicle are exposed and also the coracoid process at its ligaments. Three holes, 5 millimeters in diameter, are drilled. The first hole penetrates the tip of the acromion slightly in front of the center of the joint; the

Fig. 1.

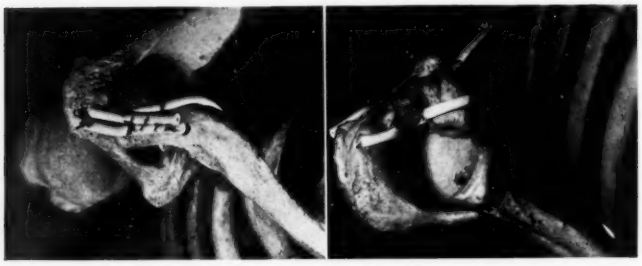
Fig. 1. Showing the anatomy of the conoid and trapezoid ligaments, the position of the 3 holes in the bones, and the fascial graft (indicated by rubber tube) in place but not yet drawn up.

Fig. 2.

Fig. 2. Showing fascial graft (indicated by rubber tube) in place and sutured, as seen from the front.

Fig. 3.

Fig. 3. Posterior view of the specimen shown in Figure 2.



Figs. 4 and 5. Superior (at left) and inferior views of same specimen showing extra reinforcement of joint capsule.

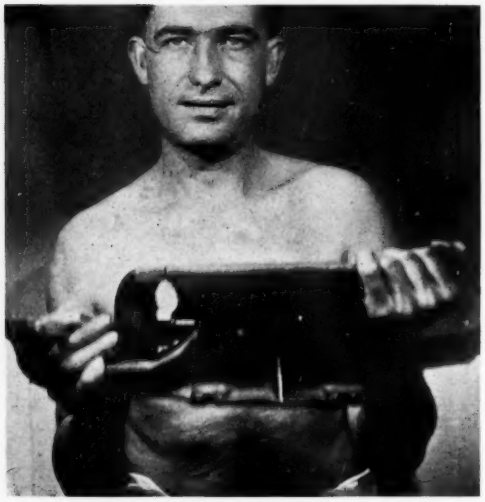


Fig. 6. Showing patient on whom this operation was performed 6 months previously. Although he is lifting a heavy anvil no difference can be detected in his two acromioclavicular joints. The original anatomy is reproduced and the function is normal.

second penetrates the outer end of the clavicle slightly behind the center of the joint, and the third penetrates the clavicle at the outer end of the trapezoid ligament.

The upper surfaces of the bones are then denuded of periosteum in a line with the holes and at the posterior border of the clavicle, so that bony contact with the fascial graft will be obtained.

A strong piece of catgut on a curved needle is then threaded down hole 1, up hole 2, then passed back of the clavicle, and with a Deschamp carrier is passed around under the coracoid process, down its inner side, up its outer side, and finally up through hole 3.

A strip of fascia lata 10 inches long and 1 centimeter wide is then taken. One end is cut in a long taper, caught in a slip knot in the middle of the piece of catgut, and drawn through each hole in turn along the course of the catgut.

A piece of No. 3 chromic catgut is passed through holes 1 and 2, tied tightly in order to hold the joint together and prevent strain on the fascial graft until the latter has grown to itself and to the bone.

The two ends of the fascia are then, by fastening a hæmostat to each, drawn up tightly, crossed over toward each other and held there while they are whipped together with a running stitch of No. 3 Turner's patent ligature silk, previously dipped in bichloride solution. The third ply of fascia is also caught in the stitch. The end pointing inward is cut off and the other end is laid across the joint to re-enforce the capsule further, and is held there by a stay suture. The wound is closed and the arm placed in a sling for 2 weeks.

ADVANTAGES

The one strip of strong fascia reproduces anatomically the conoid and trapezoid ligaments, as the two fascial strips correspond to the two borders of these ligaments. It also reconstructs the superior and inferior ligaments of the acromioclavicular joint and re-enforces the superior ligament with an extra plication. The fascial plications fuse to each other and grow to the bones by intimate bony contact.

Practically, the method gives a perfect result, as shown in Figure 6. Although the patient is lifting a heavy anvil, no difference can be detected in the contour of the joints on the two sides.

LIGATURE OF THE ANGULAR VEIN AS A PREVENTIVE MEASURE IN FACIAL CARBUNCLE

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CARBUNCLE of the face has a sinister reputation, and the upper lip is the most common site of this dreaded lesion. A complication which quite frequently heralds the oncoming of a fatal pyæmia is thrombophlebitis of the cavernous sinus.

In a series of 15 consecutive cases of thrombophlebitis of the cavernous sinus, I found that 4 were due to a furuncle or carbuncle of the upper lip, and that 3 more originated in an infected gnat bite of the nose. Thus, in nearly half the cases of the series referred to, thrombophlebitis of the cavernous sinus had its origin in a comparatively simple lesion in a circumscribed area. While reference to Eagleton's monumental monograph on cavernous sinus thrombophlebitis convinces me that this percentage is abnormally high, it is clear that infections of the upper lip and the skin of the nose are the cause of a formidable proportion of the cases of thrombophlebitis of the cavernous sinus met with in general surgical practice.

From an anatomical consideration, infection may pass from the upper lip and the nasal integument to the cavernous sinus by one of the two venous paths. That the more circuitous route through the pterygoid plexus is not often taken is shown by a study of necropsies of this condition in the records of the London Hospital Pathological Institute.[1] In 4 cases the path of the pyæmia could be traced satisfactorily along the angular vein.

It is, therefore, reasonable to assume that the angular vein, forming, as it does, a communicating link between the venous radicles of the upper lip and the ophthalmic plexus, constitutes a main channel by which infection passes into the venous system.

To forestall the spread of infection by this route, ligation of the angular veins must be a sound proposition, but the risk of the inhalation of a general anæsthetic in a febrile patient whose buccal cavity is swarming with virulent organisms, has deterred surgical enterprise in this direction.

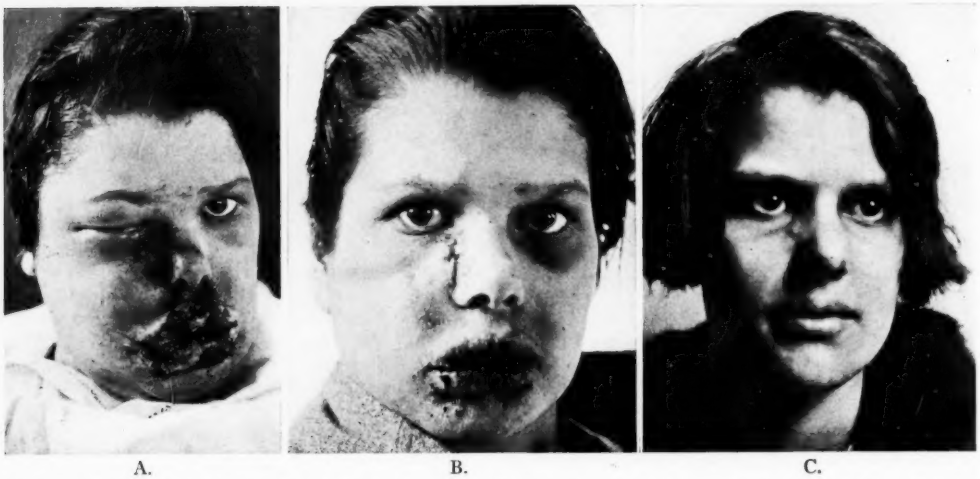
Ligature of the angular veins under local anæsthesia is a measure which is entirely free from danger, and one which can only do good. If necessary ligature may be done on both angular veins.

It is desirable to have some guide as to the most opportune moment for this intervention, for it is quite obvious that the resistance of the patient is sometimes sufficient to keep the infection within bounds. On the other hand, the necessity for timely interference must always be before us. On the whole, it is better to err on the side of activity.

A sign which foretells impending danger is spreading œdema from the lip to the inner canthus, and this is usually found in the presence of suffusion of the eyelids. As far as my own observations have gone, the premonition is invariably unilateral. If in addition to this sign there is considerable elevation of temperature, the call for action is imperative.

Fig. 1. Ligature of the angular vein.

[1] I am indebted to Professor H. M. Turnbull for permission to use these records.



A. B. C.

Fig. 2. Carbuncle of the upper lip. A, Twelve hours after ligature of angular vein. B, Same, one week later. C, Same, one month later.

TECHNIQUE

If there is any suggestion of delirium, it is advisable to administer a hypnotic 20 minutes before operation. Castor oil should be introduced into the eye, and a damp gauze covering applied over the lids, to prevent iodine running into the conjunctival sac. The lip is covered with gauze wrung out in perchloride solution; dry gauze becomes easily displaced. The angle made by the junction of the nose with the cheek is the surface marking for the vein. After novocain has been infiltrated, an incision is made commencing a little below the inner canthus and passing downward and very slightly outward for about 1 inch. There is always a lot of troublesome oozing which can be quelled by packing with gauze soaked in adrenalin. After more novocain has been injected, dissection in the wound will reveal the levator labii superioris alæque nasi. The fibers of the muscle are teased apart, and the angular vein will be found either in or beneath this muscle. It is divided between ligatures. Skin sutures and a collodion dressing complete the operation.

CASE 1. A young woman, 18 years of age, had a carbuncle on her upper lip. She had had it for 5 days. It began as a pimple which she had squeezed. The patient had considerable delirium and a temperature of 104 degrees. The right eye was completely closed by suffusion of the eyelids.

Fig. 3. Carbuncle of the upper lip. Thrombosis of the left cavernous sinus.

Fig. 4. Thrombosis of the cavernous sinus. Carbuncle of the upper lip. This illustration is taken from the author's *Physical Signs in Clinical Surgery*.

Under general anæsthesia, the right angular vein was ligatured. The carbuncle was incised through the red margin of the lip. Local applications of gauze soaked in hot magnesium sulphate solution were applied. After a slight improvement for 48 hours, on the fifth day, the patient succumbed to a terminal pneumonia complicating general septicæmia.

CASE 2. A girl, aged 16, complained of a large carbuncle which had begun 9 days previously as a pimple on the middle of the upper lip, and which had developed into a carbuncle of both upper and lower lips. It had become much worse 48 hours before admission. Examination showed an œdema spreading toward the right eye, with great suffusion of the eyelids. Her temperature was 103 to 104 degrees; associated with mild delirium.

Ligature of the right angular vein was made and intravenous mercurochrome was administered followed by local treatment of the carbuncle with hot magnesium sulphate fomentations. Rapid improvement resulted and the patient was discharged 11 days later.

CASE 3. A man, 60 years of age, was admitted with a carbuncle of the upper lip of 3 days' history. His temperature was 103 degrees. There was œdema spreading to the right eye. The angular vein was ligatured and whole blood was injected around the periphery of the carbuncle. Hot gauze soaked in hot magnesium sulphate solution was applied locally. A blood culture grew a staphyloccocus. Intravenous mercurochrome was administered on the second day. Seventeen days later the patient had recovered sufficiently to return home.

Case 1 occurred 4 years ago. I now believe a general anæsthetic is absolutely contra-indicated in these cases. As regards the local treatment of a carbuncle, I have given up incision, and simply inject the patient's own blood into the tissues around the carbuncle and apply hot moist dressings. This, combined with general treatment, has given satisfactory results in carbuncles in all situations.

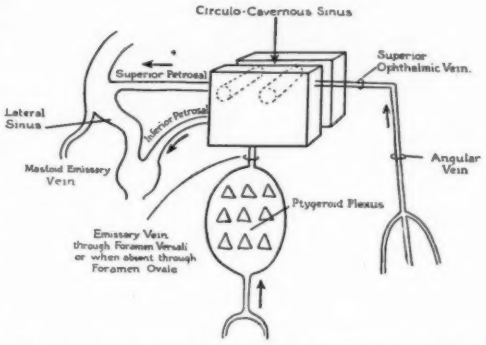


Fig. 5. The cavernous sinus and its connections (diagrammatic). Taken from the author's article in the *Clinical Journal*.

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A SHORTER TECHNIQUE FOR THE COFFEY OPERATION IN CANCER OF THE RECTUM[1]

By DUDLEY SMITH, M.D., F.A.C.S., San Francisco, California
From the Department of Surgery, University of California

FOR many years the principles of operative procedure in cancer have been definitely standardized, but many surgeons seem to disregard these fundamental principles in operating for cancer of the rectum. Unless the operation removes the lymphatics in the three zones of spread, as so well described and illustrated by W. E. Miles (1), in the *British Medical Journal*, it is not a complete operation and the percentage of 5-year cures will not be as high as it should be. This removal can be done only by a radical abdominoperineal operation (Fig. 1).

The one-stage abdominoperineal operation of Miles unfortunately carries with it a primary operative mortality of 25 per cent or more even in his skillful hands. This high immediate operative mortality lends strength to the argument for less radical procedures.

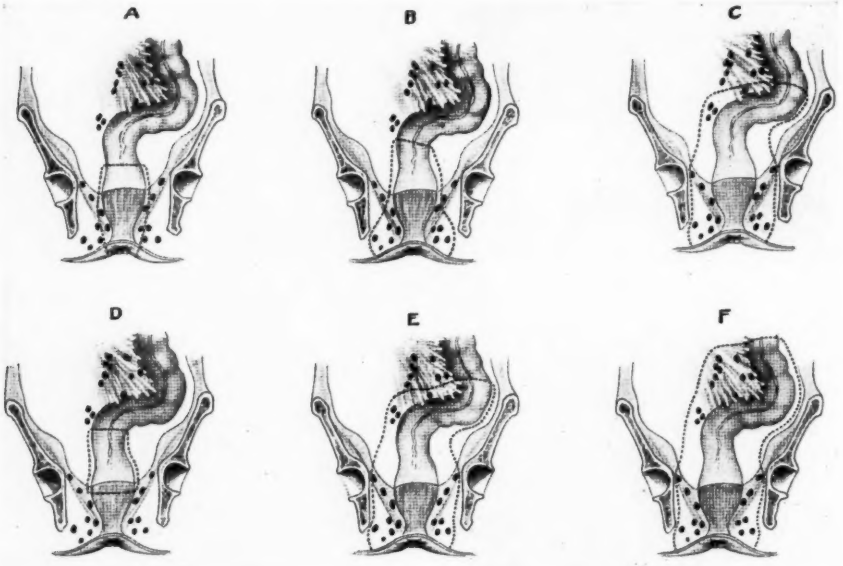

Fig. 1. A, Diagram showing the restricted nature of Kraske's operation. The rectum is merely dissected out as a tube containing a cancer, and the vulnerable tissues of the upward, lateral, and downward zones of spread are left.

B, Diagram showing the first step in the evolution of the radical operation. The peri-anal skin and the ischiorectal fat were widely removed as these tissues have been found vulnerable to recurrence.

C, Diagram showing the extension of the operative field as a further step in the evolution of the radical operation. In addition to the peri-anal skin and the ischiorectal fat, all of the levator ani muscles and the lower part of the pelvic mesocolon were included with the portions which were dissected out as these tissues were found to be highly vulnerable.

D, Diagram showing the limited character of the removal in perineal resection and vaginal resection.

E, Diagram showing how much of the vulnerable tissues of the three zones of spread is left behind by the abdomino-anal operation. Even when the proximal end of the colon is brought down to the anus, the vulnerable tissues of the lower zone are left.

F, Diagram showing the final stage in the evolution of the radical operation. Whereas the vulnerable tissues in the lateral and downward zones of spread may be removed completely by an operation carried out from the perineum alone, the greater part of these contained in the upper zone remain out of reach. These tissues, which correspond to the axilla in the breast operation, can be removed only by the radical abdominoperineal method. (From Coffey's modification of Miles' illustrations.)

[1] Read before the American Proctologic Society, Philadelphia, May 12, 1927.

Fortunately, however, Robert C. Coffey has devised an abdominoperineal operation which is done in two stages, has in his hands an operative mortality of about 5 per cent. No operation can be more complete and thorough. Coffey in 1924 (2), presented a clear and well-illustrated description of his operation, which includes the following steps:

1. Long right rectus incision.
2. Ligation of the superior hæmorrhoidal artery and vein.
3. Mobilization of the sigmoid and rectum.
4. Clamping and cutting of sigmoid, drawing proximal segment through stab wound in left rectus for colostomy.
5. Pushing rectal tube up through sigmoid to clamp on distal segment, placing purse-string suture around the gut below clamp, removing clamp, end inverted, fixing end of rectal tube to inverted end of gut, trimming mesenteric fat well down to the bottom of the pelvis, inverting sigmoid and rectum, and drawing them out through the anus.
6. Closure of raw surfaces and formation in the male of an extra-abdominal peritoneal tube for drainage through the lower angle of the abdominal incision. In the female, the peritoneum and abdomen are closed in the usual way and drainage is secured through a hole in the posterior vaginal fornix.

In cases in which the cancer has caused sufficient obstruction to prevent inversion of the sigmoid and rectum, Coffey double-clamps the rectum, either above or below the cancer, cuts between the clamps with the cautery and removes the sigmoid and the portion of the rectum above the lower clamp, leaving the clamp on the stump of the rectum, the handles protruding in the male from the lower angle of the abdominal incision, and in the female from the vulva. This is a long operation. Coffey says: "There is much sewing to be done in this operation, which requires a great deal of time. In short, the radical operation for cancer of the rectum is one of the largest in surgery."

It has been my purpose to shorten the operation as much as may be without abridging its thoroughness. We have not found that better results follow when the sigmoid is inverted than when the gut is clamped off, and the tissues above removed. Moreover, if lymphatic extension is present in the mesentery or the retrorectal fat, the trimming off of the fat well down into the pelvis is not without danger of transplanting cancer cells. Accordingly, the clamp without

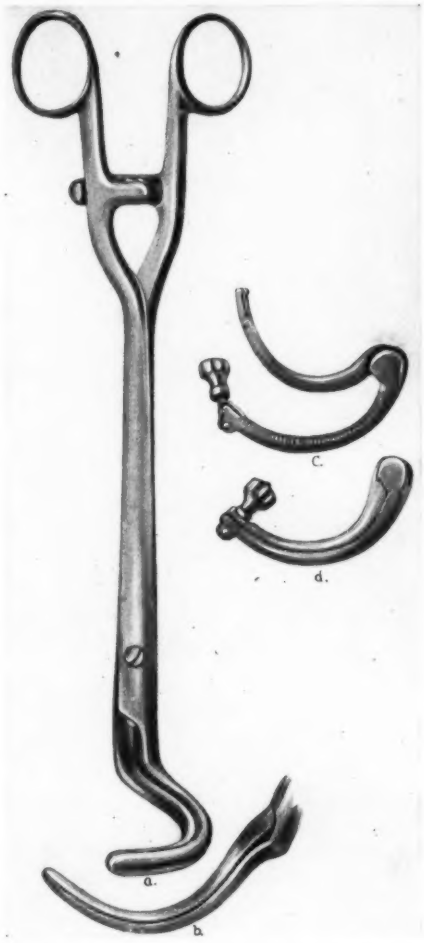

Fig. 2. Author's clamps. *a*, Long clamp with jaws almost at right angles to the handles. *b*, Shows the curve of the jaws of clamp *a* corresponding to the curve of clamp *c,d*. Bite 3 inches long. *c*, Clamp without handles, open. *d*, Clamp closed. Bite 2½ inches long.

handles (Fig. 2, *c,d*) was devised. The technique of Coffey as already outlined is followed up to and including the fourth step. The fifth step is elimininated and in its stead the clamp is placed around the rectum, either above or below the growth, depending upon its location, closed tightly by means of a long handled, strong jawed forceps, and the clamp securely fastened by the thumb screw. The rectum is clamped just above with a right angled forceps with curved jaws,

Fig. 3. The sigmoid and rectum have been mobilized down to the coccyx and the rectum separated from the bladder; the rectum is double clamped below the cancer and is being transsected with the electrocautery. If the cancer is located so far down that the clamps cannot be placed below it, they are placed above the growth and it is removed with the stump of the rectum at the second stage of the operation.

corresponding to the curve of the other clamp (Fig. 2, *a*, *b*). The gut is then severed with the cautery between the clamps (Fig. 3), the mobilized rectum and sigmoid removed, and the stump of the rectum where it is held by the clamp is thoroughly sterilized with the cautery. A pack of gauze is placed over the rectal stump and around the clamp, completely covering it so as to protect the adjacent tissues from pressure. Over this is placed a piece of rubber dam, and the peritoneum sutured over it (Fig. 4). The abdomen is closed in the usual manner leaving the clamp in the pelvis until the second stage of the operation is performed 10 days later.

We secure drainage by making a small incision alongside the coccyx through which 2 rubber tubes are passed upward into the cavity back of the mobilized rectum (Fig. 4).

Objection may be offered to drainage through a posterior stab wound on the ground that it is uncomfortable for the patient, but we believe dependent drainage to be advantageous and we have not found that it adds to the discomfort of the patient.

This procedure saves the time required to perform the fifth step of the Coffey technique, and that part of the sixth step in the male wherein the extra-abdominal peritoneal tube for drainage is formed. Moreover, no handles protrude from the abdominal incision nor from the vulva, which is advantageous.

The second stage of the operation is a posterior resection of the stump of the rectum, ischiorectal fat, levators, and peri-anal skin. The patient is placed in the prone position with head and feet lowered. Sacral analgesia is used. The incision is made over the sacrum in the midline running around the anus and including a wide area of the peri-anal skin. The coccyx is removed. The dissection is made wide of the rectum. The levators are cut as far distal to the rectum as possible and much of the dissection can easily be made with the fingers, following the line of cleavage caused by cutting off the blood supply from

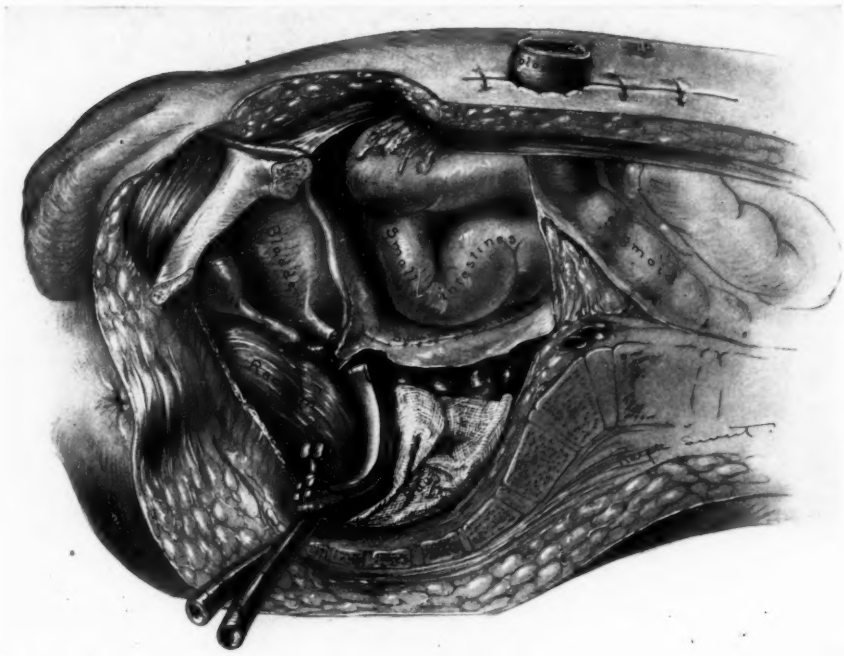

Fig. 4. The segment of sigmoid and rectum from the colostomy to the clamp has been removed, the gauze pack placed in the pelvis and over it a piece of rubber dam, the peritoneum and abdominal incision closed, two rubber drainage tubes inserted into the cavity back of the mobilized rectum through an incision alongside the coccyx. The gauze pack should be placed completely around the clamp to protect adjacent tissues from any possible pressure.

above at the first operation. There is very little bleeding and that only from the skin and anal muscles. The clamp, gauze pack, and rubber dam are removed with the rectum and a surprisingly clean cavity is left. The cavity is then packed and healing is brought about by granulation. The patient is ambulatory after about 2 weeks.

This technique is equally applicable in the male or female, in non-obstructing or obstructing cancers and for growths located at any point in the rectum or lower sigmoid.

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2. Coffey. Surg., Gynec. & Obst., 1924, xxxviii, 723.

DRAINAGE OR NON-DRAINAGE AFTER THYROIDECTOMY

By FRANK H. LAHEY, M.D., F.A.C.S., Boston

IT has been very generally accepted that the introduction of drains following thyroidectomy is an essential part of the operative procedure of partial removal of the thyroid gland. This dictum that drainage is necessary in thyroidectomy has been handed down from year to year, particularly as relates to the operation when it is performed upon toxic goiter, either of the primary hyperthyroidism or secondary hyperthyroidism variety.

One of the main indications for drainage in toxic goiters has been the assumption that unless a drain is introduced after operation, a good deal of the thyroid secretion which is spilled into the wound by cutting, squeezing, and pulling upon the gland will be absorbed, and will result in a severe postoperative thyroid reaction.

It has further been assumed that the absorption of wound products other than the secretion from the thyroid itself produces undesirable postoperative thyroid reactions.

As a measure to offset dangerous postoperative thyroid reactions in cases of intense thyroidism, it has been suggested that following partial removal of the gland, the wound be left open and packed with gauze or rubber dam until the second stage of the removal of the gland can be carried out.

Our experiences with the matter of drainage and wound packing following thyroidectomy have

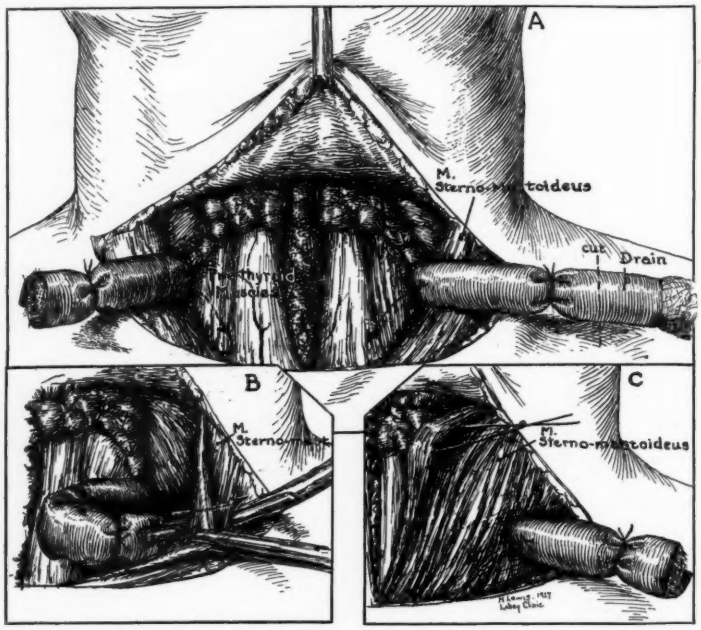

Fig. 1. A. The drains brought out through the external angles of the wound in front of the bellies of the sternomastoid muscles. B, A hæmostat has been passed through the belly of the sternomastoid and the end of the cigarette drain has been grasped, preparatory to pulling it through the muscle. C, The drain has been pulled through the sternomastoid at the outer angle of the wound. Note the stitch placed between the anterior edge of the sternomastoid and the middle of the suture line in the prethyroid muscles, resulting in the pulling of the sternomastoid over this suture line so that it does not become adherent to the skin flap. This procedure was developed by Dr. R. L. Mason in this clinic.

been quite contrary to such theories and for that reason are here set down.

It has been our aim, particularly during the last few years of our operative experience with thyroid diseases, to eliminate drainage in every possible instance, and we have closed all thyroid wounds tightly except when the superior mediastinum had been opened, when a considerable pocket remained, as after the removal of a large adenoma, or when an oozing existed that could be controlled best by means of a small pressure gauze pack. That drainage has been but rarely employed in our hands is evidenced by the fact that, in the years 1925 and 1926, a total of 1,810 thyroid operations of all varieties were done, and of those but 20 per cent were drained. These figures include the introduction of drains of any variety, even the introduction of small slips of rubber dam just beneath the skin flap when oozing in this flap cannot be adequately controlled, as is the case often when the flap is raised a second time in two-stage removals of the gland, as by two separate hemithyroidectomies. If the figures merely included those in which drains were introduced down to the remnants of thyroid itself, beneath the prethyroid muscles, the percentage of cases drained would be very much smaller.

With this plan of non-drainage following partial thyroidectomy, we have not been disturbed by undue thyroid reactions; our mortality during these 2 years has not been greatly elevated—in exophthalmic goiter, 0.99 per cent; in toxic adenomata, 1.77 per cent—and we have been more and more convinced of the desirability of closing thyroid wounds without drainage except for definite technical reasons, such as oozing, dead space, or openings leading into the mediastinum.

Should it be necessary to employ drainage, we urge strongly against the use of stab-wound drainage below the center of the incision, as has been so commonly employed in the past. The scar which remains following drainage at this point is thick and is quite unnecessary. It is located so that it is very noticeable as it cannot be covered by beads.

We would also urge strongly against bringing the drain out through the center of the transverse incision for the removal of the thyroid. We employed this plan in the past and gave it up because of the fact that the scar tissue which filled in the midline drainage sinus so fixed the skin to the trachea and thyroid remnant that the median portion of the scar was often held up in a most unsatisfactory and disfiguring manner.

We have now for some time led the drain or

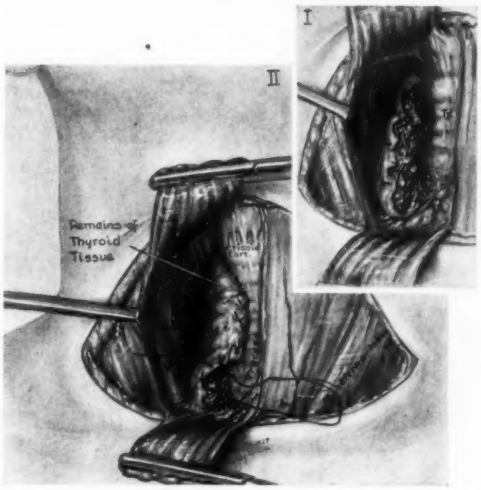

Fig. 2. I, This illustration shows the remnant of thyroid tissue following the partial removal of the thyroid lobe. II, shows the method of suturing the outer cut edge of the thyroid remnant over against the trachea, so that all of the open, oozing surface of the gland is buried, and the smooth posterior surface of the gland then presents. This results in complete control of all oozing and practically the reconstruction of a new lobe.

drains, when it is necessary to employ them, out through the external angle of the wound, where the skin does not become adherent to underlying structures and no disfigurement results.

In certain cases in which the drains are to be brought out at the external angle of the wound, it will be found that the sternomastoid muscles lie so far forward that the drain cannot be brought out without angulation. In these cases we have passed the drains through the bellies of that muscle by bluntly separating its fibers with scissors at the level through which the drain is to emerge.

Following non-drainage after thyroidectomy, we have not had accumulations beneath the prethyroid muscles requiring secondary opening and have not had difficulties with wounds breaking down. The postoperative thyroid reactions have not increased in numbers or in intensity, and the operative mortality has not been high.

We have frequently had small pockets of serum accumulate directly in the wound scar 10 to 12 days after operation and occasionally sooner, but have never had any difficulty in caring for them by evacuation of the serum with a probe for a few days when the patient returns to the clinic for dressings.

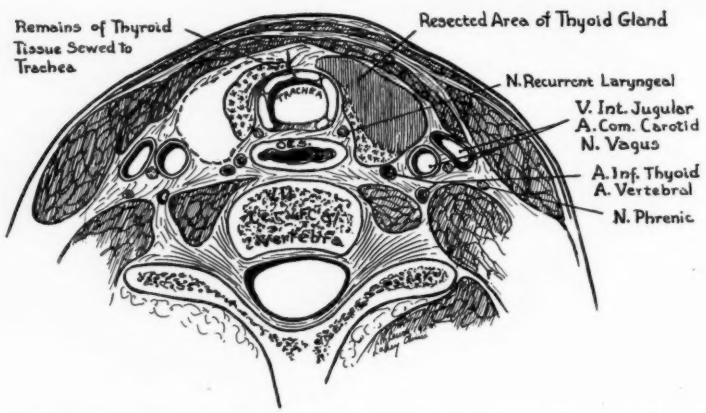

Fig. 3. This cross section diagram of the thyroid and its relations shows the entire thyroid lobe on one side with the area which is to be removed shaded, so that the shape and relative size of the remaining remnant may be seen. On the other side this remnant is shown folded upon itself (a considerable factor in the control of the oozing), and its outer edge sutured to the pretracheal tissue. This demonstrates how the smooth posterior surface becomes the anterior surface and a new lobe is constructed.

We have occasionally had considerable accumulation beneath the skin flap itself. This has usually occurred within 5 to 6 days after operation, and in the same way we have had no difficulty caring for such pockets by separating the wound edges at the most prominent point, evacuating the contents of the pocket, and employing hot boric applications.

During the time we have been closing thyroidectomy wounds without drainage, we have had no trouble with breaking down and separation of the sutured prethyroid muscles. Wounds cannot be closed without drainage, of course, unless meticulous pains are taken to insure complete hæmostasis and to obtain a very dry wound when the operation is completed. We have accomplished this by ligation of all small vessels in the skin flap and on the muscles to control oozing from these points, and finally have controlled all oozing from the cut surface of the thyroid remnant which is to be left behind by suturing the outer edge of the thyroid remnant to the pretracheal tissue as described by us in SURGERY, GYNECOLOGY AND OBSTETRICS, so that the cut surface of the thyroid is held firmly against the trachea and the smooth, uncut posterior surface of the thyroid remnant presents uppermost on the reconstructed and remaining thyroid remnant.

CONCLUSIONS

Drainage following thyroidectomy is necessary only for technical reasons—to take care of uncontrollable oozing, to eliminate dead spaces in which blood may pool and become infected, and to protect the opened superior mediastinum against infection.

Thyroid reactions following operations upon the gland are no greater when the wounds are closed without drainage than when drained, and in our experience are not related to this factor.

A BLOOD-VESSEL CLIP SET FOR INTRACRANIAL WORK

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FROM the time of the appearance of Cushing's clip forceps, holder, former, and scissors, up until 2 years ago, we have been entirely dependent upon them for controlling hæmorrhage of the cerebral vessels. Their use has been associated with varying success but unfortunately there were many instances when we met with great difficulty in handling them; the clips were sometimes imperfectly formed, as a result would not fit the holder properly, and consequently could not be applied to the bleeding vessel successfully. A further cause of trouble, we believe, was the fact that wire was used, with the result that the arms of the clip crossed when the clip was pressed together. For that reason, ribbon has been substituted. Furthermore, the stop pin used in this clip holder, as described later, prevents lateral movement of the clip and also prevents the clip from slipping away from the vessel when pressure is applied to the clip at its apex.

I have worked out a set of instruments for this purpose which produces a clip uniform in size and which any assistant can make without difficulty. The new outfit, complete, consists of a clip cutter (Fig. 1), a clip rack (Fig. 2b), and a clip holder (Fig. 2a and b).

The clip cutter is an instrument of tooled steel which cuts a uniform clip of silver ribbon. This is accomplished by feeding the flat silver ribbon through a slot in the block of the cutter (Fig. 1*a*) and when the jaws of the cutter are closed the flat wire is cut and molded into clips (Fig. 1*b*). These clips are uniform in size, and the length of each side of the clip is identical, i.e., the apex is equidistant from the base. These are placed on the rack (Fig. 2*b*), which has a broad corrugated base. The jaws of the clip holder are placed in the grooves of the corrugated base and the handles brought together (Fig. 2*b*). The holder is withdrawn and the clip is in place (Fig. 2*c*). The clip may also be picked up without unlocking the handles by slipping jaws over rack.

The jaws of the holder are counter-sunk half the thickness of the ribbon, and the pin in the jaw is machined out to the thickness of the clip (Fig. 2*a*, arrow). The clip is held in place snugly by the jaws and pin, thus preventing any lateral movement. The pin in addition prevents the clip from slipping up into the clip holder, an experience that is not infrequent when holders without the stop pin are used. This important feature cannot be too strongly emphasized.[1]

The making of clips with this instrument is very simple, and it is well to make them up before an operation. Experience has shown that frequent boiling of the clip cutter dulls the sharp

[1]McKenzie has very recently described a clip and holder similar to this. It seems worth while, however, to make this report since 2 years' experience has shown us that the pin-stop in the holder, though it seems a very insignificant point, adds tremendously to the efficiency of the instrument.

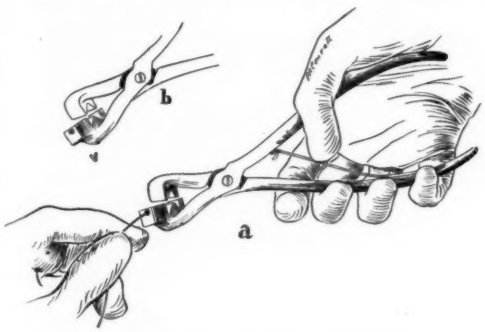

Fig. 1. Clip cutter and detail of instrument.

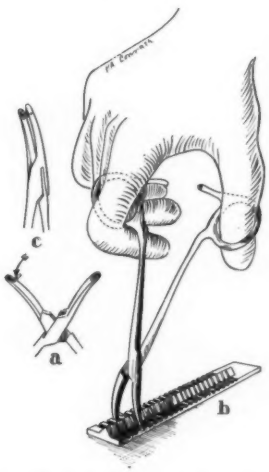

Fig. 2. Clip rack and detail of clip forceps

edge of the tooled steel which makes the important sharp angulation of the clip. Passing the holder through saline after the application of each clip keeps the jaw clean and prevents the sticking of the clip in the groove into which it fits.

This instrument has been in use in the neurosurgical clinic of Washington University School of Medicine and Barnes Hospital for the past 2 years and was demonstrated to the members of the Society of Neurological Surgeons at their meeting in St. Louis in December, 1926.

AN OVERHEAD FRAME FOR PLASTER BODY—SPICA CASES

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ANY case demanding an application of a plaster body cast with either single or double spica of the hips, thighs, and legs is a great care from the treatment and nursing standpoint and frequently the patient suffers considerable discomfort. The prevention and treatment of pressure sores; the changing of the bed linen; any inspection of the perineum, buttocks, or sacrum; any dressing of the back and the other usual daily nursing cares are problems of great concern. Cases of this type are frequently improperly handled, thus causing unnecessary pain, as well as increasing the possibility of further damage to the patient.

We have found that the overhead frame herewith described (Figs. 1 to 6) is a great aid in treating and nursing the plaster body—spica cases; furthermore it eliminates many of the complications and difficulties encountered in such cases.

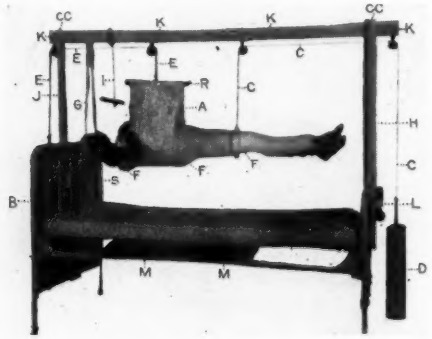
The frame is of very simple construction, consisting of 4 pieces of wood, 2 by 4 inches, and a crosspiece (38 by 1.5 by 1.5 inches) for extension on the legs when necessary. The frame fits any hospital bed and alterations can easily be made to fit any type of iron bed.

The frame is also useful for treating fractures about the hip joint and fractures of the neck and shaft of the femur, especially if extension is desired; either a plaster cast and extension, or suspension and extension with the thigh and leg in a Thomas splint being used. We have used it to considerable advantage in fractures of the pelvis.[1]

Figure 1 shows the patient suspended following application of sufficient weight to raise him off the bed. *K* shows crosspiece 2 by 4 by 8 feet, 4 inches long, which is attached to the foot and head pieces at *CC*, *CC*. *K* extends 6 inches beyond *CC*, *CC* at the foot and head pieces to allow the weights to clear the bed. Four ½ inch holes, 2 inches apart, are made at points *CC*, *CC* on piece *K*, to allow for any adjustment which may be desired of the crosspiece *K* to the head and foot uprights.

J shows head piece 2 by 4 by 4.5 feet long. *H* shows 2 foot up-rights (see also Figure 4) which are the same dimensions as the head upright *J*. Two foot uprights are used to steady the frame.

[1] H. Earle Conwell. Fractures of the Pelvis. Scudder's, Treatment of Fractures, 10th ed.



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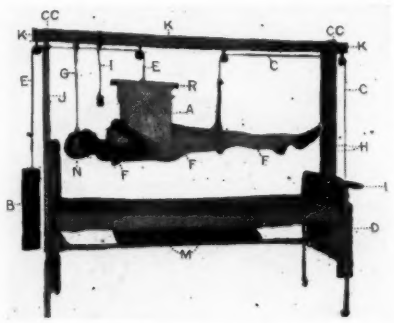

Fig. 2.

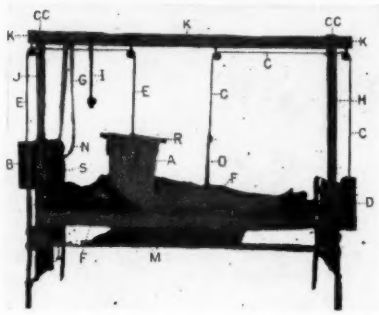

Fig. 3. Showing patient on bed. Weights from *B* and *D* have been gradually removed.

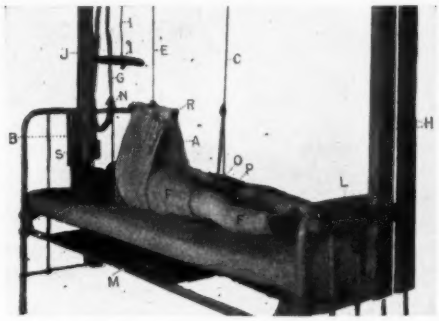

Fig. 4. Close up view, showing details of cast and suspension apparatus.

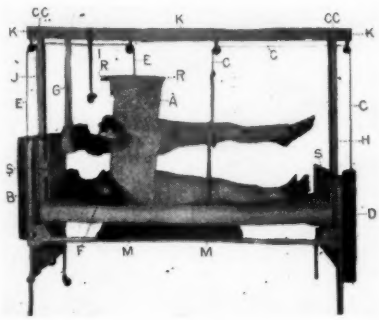

Fig. 5. Double exposure, showing patient suspended and lowered.

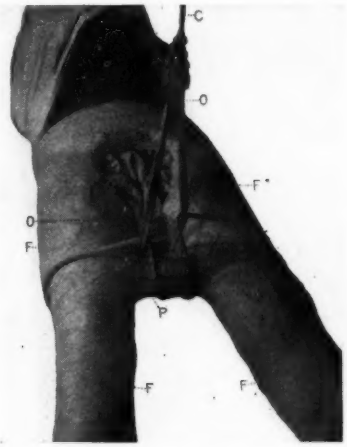

Fig. 6. Showing type of knot used in the rope *O* which is applied around the legs *F*, *F* and the crosspiece *P*. This crosspiece, *P*, which is made of plaster, should always be applied because it strengthens the cast as well as allows the patient to be moved painlessly.

L shows foot crosspiece 1.5 by 1.5 by 38 inches. This is used in cases in which traction on the legs is desired. The screw pulleys are 2½ inches in diameter. *M*, *M*, show board splints used under the bed to prevent sagging of the mattress.

The patient is suspended with the head and foot weights *D* and *B* by attachments of rope *C* to the double plaster spica *F*, *F*, and rope *E* to the wooden piece *R* to which the muslin sling *A* is attached. *A* shows the muslin sling, 24 inches by 6 feet, which fits around the patient's body cast; and at one end of the sling is a loop for the wooden piece *R* which measures 1.5 by 1.5 by 24 inches. Buckles and straps attached to the muslin sling *A* enable it to be fastened around *R*. The rope *E* is attached to the center of *R*.

G is a piece of bandage around the crosspiece *K* and has a large handkerchief *N* tied to each end for the head rest. *I* is a swing, rope and broomstick for patient to pull himself up. *S* shows blocks, (Fig. 5) 4.5 inches long by 1.5 by 1.5, which fit on each side of the upright iron rods on the foot and head of the bed and stabilize the frame.

It can easily be seen that if enough weight is applied to *D* and *B* the patient can be raised at any height from the bed without difficulty and can be suspended for a considerable length of time without great inconvenience to the patient. If any elevation of the patient's head and chest is desired, weights can be removed from foot weight *D*.

Dressing of the perineum can be done easily. Any dressing of the back can be carried out by unbuckling the straps on the right or left side of muslin sling *A* depending on the location of the wound. The patient is perfectly comfortable and does not suffer from a suspension over a prolonged period.

CORRESPONDENCE

OPERATING RETRACTORS WITH THE FEET

To the Editor: I wish to call the attention of abdominal surgeons to the advantage of operating their retractors with the feet instead of by hand.

The contrivance is simple. An ordinary gauze bandage is passed around under the table in a loose loop reaching to the floor; each end is fastened to a retractor by a strong thumb clamp. The feet of the operator, treading upon or secured to this loop of bandage, by motions right and left either of foot, toe, or knee make desired traction.

A firm retraction of either or both walls of the wound is thus afforded as desired entirely at the operator's command whether seated or standing. The maneuver with a little practice becomes quite automatic. An unobstructed view of the interior is obtained without obstruction of light. One or more assistants are dispensed with as is the necessity for directing their action; much time and disturbance is saved.

A more elaborate mechanism by which bandages are replaced by metal chains by which hooks, snaps, or other holders grasp the retractors; a frame or movable calipers on the principle of a self-retaining retractor; foot pedals and clamping adjustment attached to the bars of the table through which the bands pass in order to hold them conveniently as well as "block and tackle" pulleys to increase the retraction with less foot motion etc., have been suggested. Such detail could be left to an ingenious instrument maker should they be desired. Everything, however, which detracts from simplicity and asepticity should be dispensed with unless of marked advantage. If additional retraction in any direction is desired, there is nothing to prevent an assistant making it when called upon to do so, but this is not usually necessary.

I am employing the method described in my operating room where it is being commented upon.

O'NEILL KANE, M.D., F.A.C.S.

Kane, Pennsylvania

EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

FRANKLIN H. MARTIN, M.D.....Managing Editor
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APRIL, 1928

INFLUENCE OF PREGNANCY ON THE FUNCTION OF THE GALL BLADDER

IT has been observed clinically that pregnancy is an etiological factor in disease of the gall bladder. In 1911, W. J. Mayo stated that most women with disease of the gall bladder who have borne children date the onset of symptoms from a particular pregnancy. Pre-existing cholecystitis often undergoes exacerbation during pregnancy. It is not uncommon for attacks of gall-bladder colic to become so frequent and severe, or symptoms of acute or subacute cholecystitis so apparent, that operation on the gall bladder must of necessity be performed during pregnancy. It has been demonstrated that such an operation may be done successfully and without undue risk.

It has been assumed that disease of the gall bladder during pregnancy is caused by an increase in the cholesterol content of the blood and a certain sluggishness of the biliary tract produced by pressure from the enlarging uterus. Mann and Higgins showed recently that the emptying time of the gall bladder in most pregnant dogs, guinea pigs, and gophers is delayed. Following the ingestion of the standard fat meal of egg-yolk and cream (Boyden), the gall bladder of the pregnant animal of these three species emptied partially in early pregnancy and less completely as pregnancy progressed. Mann and Higgins believe that a larger number of pregnant animals of these and other species, including man, must be examined before it can be accepted as a physiological fact that the gall bladder of the pregnant animal is slow to empty. They conclude: "However, three considerations are pertinent to the subject. The pathological conditions often associated with pregnancy which may directly or indirectly have some relation to the mechanism of the biliary tract are (1) hyperemesis, (2) eclampsia, and (3) gall stones."

Is this delay in the emptying time of the gall bladder the result of mechanical, chemical or nervous influences? The mechanical factor apparently has been ruled out. Is it the result of chemical changes in the blood due to pregnancy? Many investigators have attacked the problem of the cause or causes of hyperemesis and eclampsia from the chemical angle. Among these, Hofbauer has shown that acute poisoning by histamine, a protein derivative, produces pathological changes in animals suggestive of those in women who die from eclampsia, and that chronic histamine poisoning produces changes similar to those resulting from pernicious vomiting. Is it the result of action through the sympathetic nervous system? An indication of the influence of the sympathetic nervous system is the frequent observation that pylorospasm occurs during labor, preventing the downward

passage of food even throughout protracted labor. A case may be cited: that of a woman who swallowed air and as a result her stomach became distended three times during the second stage of labor. Each time the stomach became visibly distended, the patient complained of epigastric pain and the uterine contractions ceased until the stomach was emptied by tubing. Another clinical observation is the induction of uterine contractions following vigorous intestinal peristalsis such as that produced by castor oil. Is the retardation of the gall-bladder function due to a similar mechanism? Is the delayed emptying of the gall bladder associated with physiological lowered hepatic function during pregnancy? Is it a part of a retardation or lowering of the function of the upper digestive tract? Artz has observed that gastric acidity is low in certain normal pregnant women and still lower in certain patients with hyperemesis. Is it due to or a part of reversed intestinal peristalsis which may occur during pregnancy? ROBERT D. MUSSEY.

TREATMENT OF POSTOPERATIVE HÆMORRHAGE FOLLOWING GASTRO–ENTEROSTOMY

HÆMORRHAGE following gastro-enterostomy, rare though it may be, is a most alarming, distressing, and embarrassing sequel to an otherwise satisfactory operation, and it may tax the best judgment of the surgeon to carry on to a happy and successful outcome.

Hæmorrhage is most likely to occur either at the ends of the stoma or from one of the larger vessels along its margin.

In performing gastro-enterostomy, the utmost care should be taken to obtain accurate approximation of the mucosa, and to control the sub-mucosal vessels. A lockstitch for the anterior as well as the posterior row of sutures is to be preferred, the *anterior mucosal border being turned away from the lumen.* This is exceptionally important because cases of postoperative hæmorrhage have been reported in which the bleeding came from the anterior border, due to an inverting mucosal suture which did not control the vessels (Horsley). When a definite vessel can be identified, a double lock or back stitch should be used about it. When the gastro-enterostomy is performed without clamps, and when all bleeding points may be seen and grasped, the chances of postoperative hæmorrhage should be less. If clamps are used, two simple straight intestinal clamps suffice. After the posterior row of sutures is completed, and again after the anterior row is finished, if any possibility of hæmorrhage still exists, these clamps may be loosened, any bleeding points may be seen and sutured or ligated, and the clamps again tightened. This is especially advantageous when the gastric vessels are abnormally large or dilated.

Dean Lewis has suggested that he considers that the best hæmostasis is obtained with three rows of sutures: serosa, submucosa, and mucosa.

When clamps are used, approximation of the ends of the gastro-enterostomy incision is facilitated by grasping a sufficiently large section of stomach and jejunum. Thus the stoma is made long enough and yet on rounding the corners, tension on the suture line is avoided by not approaching too close to the clamps.

Slow or minor hæmorrhage, the vomiting of dark blood, 8 to 10 hours after the operation, with gradual tachycardia, requires little more than the withholding of fluids by mouth, the intravenous, subcutaneous, or per rectum administration of saline solution, transfusion, or occasionally lavage. For lavage, a weak soda and salt solution at a temperature

of 120 degrees F. is especially recommended by Horsley.

But when hæmatemesis begins 3 to 4 hours after the operation with definite clotted blood, and is repeated 3 to 4 hours afterward, the pulse rate is increased, and the blood pressure descends, there is definite pallor, and the hæmoglobin and red blood count show well-marked hæmorrhage, a more drastic and direct attempt to control and check the hæmorrhage must be considered,—that is, the advisability of obtaining direct control of the hæmorrhage through a gastrotomy incision must be taken under consideration.

The patient is returned to the operating room. Under local, light gas, or ethylene anæsthesia, the abdominal wound is re-opened, or a new epigastric midline incision is made, the anterior wall of the stomach about opposite the gastro-enterostomy is grasped, and a longitudinal incision 6 to 7 centimeters long made into its cavity, about midway between the lesser and greater curvature. This incision is then held open by stay sutures or Allis forceps and small retractors. The clots and débris in the stomach are gently sponged out or aspirated, and the gastro-enterostomy wound is grasped by placing a stay suture at each end. These are drawn upon, and the gastro-enterostomy is inverted into the stomach lumen where a lockstitch of chromic catgut No. 00 can be rapidly thrown around the entire circumference of the gastro-enterostomy. When the hæmorrhage is controlled, the gastro-enterostomy is again dropped back, and the anterior gastrotomy wound closed with two or three layers of sutures.

This procedure has been used in 2 cases with uneventful recovery.

W. L. Estes, Jr.

A DE LUXE EDITION OF OLD BOOKS IN SURGERY

THE ever changing conceptions as to the practice of surgery constitute one of its fascinations. As the centuries go by certain masterpieces live beyond the ephemeral contribution of their day, and a study of these portrays the definite advances in our profession. Some years ago, Dr. Alfred Brown undertook the selection and review in brief of the great books that mark some of the epochs in surgery. These have appeared monthly in Surgery, Gynecology and Obstetrics. The material collected is so valuable that it is with pleasure we learn that Dr. Brown now contemplates publishing the reviews in slightly amplified form with the beautiful reproductions of the frontispieces, title pages, and illustrations as they appeared in his isolated publications. This collection will be published in an edition of about three hundred pages with attractive typography, and wide margins, and will be well bound in distinctive boards—a book that will appeal to all book lovers and make a valuable addition to the doctor's library or an attractive gift for his friends.

It will be published by Dr. Brown not primarily for profit but as a labor of love from one book lover to another. The expense will be such that unless there is sufficient interest on the part of the profession as evidenced by subscriptions received in advance to cover at least the printing costs it will not be advisable for the author to bring out the book. The subscription price will be eight dollars and it is hoped that those of our readers who are interested will write to Dr. Alfred Brown, 1618 Medical Arts Building, Omaha, Nebraska, making reservations for copies.

MASTER SURGEONS OF AMERICA

PAUL FITZSIMONS EVE[1]

PAUL FITZSIMONS EVE, A.M., M.D., LL.D., was born at Forest Hall, on the Savannah River, six miles below Augusta, Georgia, June 27, 1806. He was the youngest of the eleven children, son of Captain Oswell and Aphra Ann Eve. On the father's side he was of English descent, and on the mother's side was of the Scotch-Irish blood. His father had been captain of a Pennsylvania company before the War of the Revolution. Captain Eve had as a schoolmate Dr. Benjamen Rush.

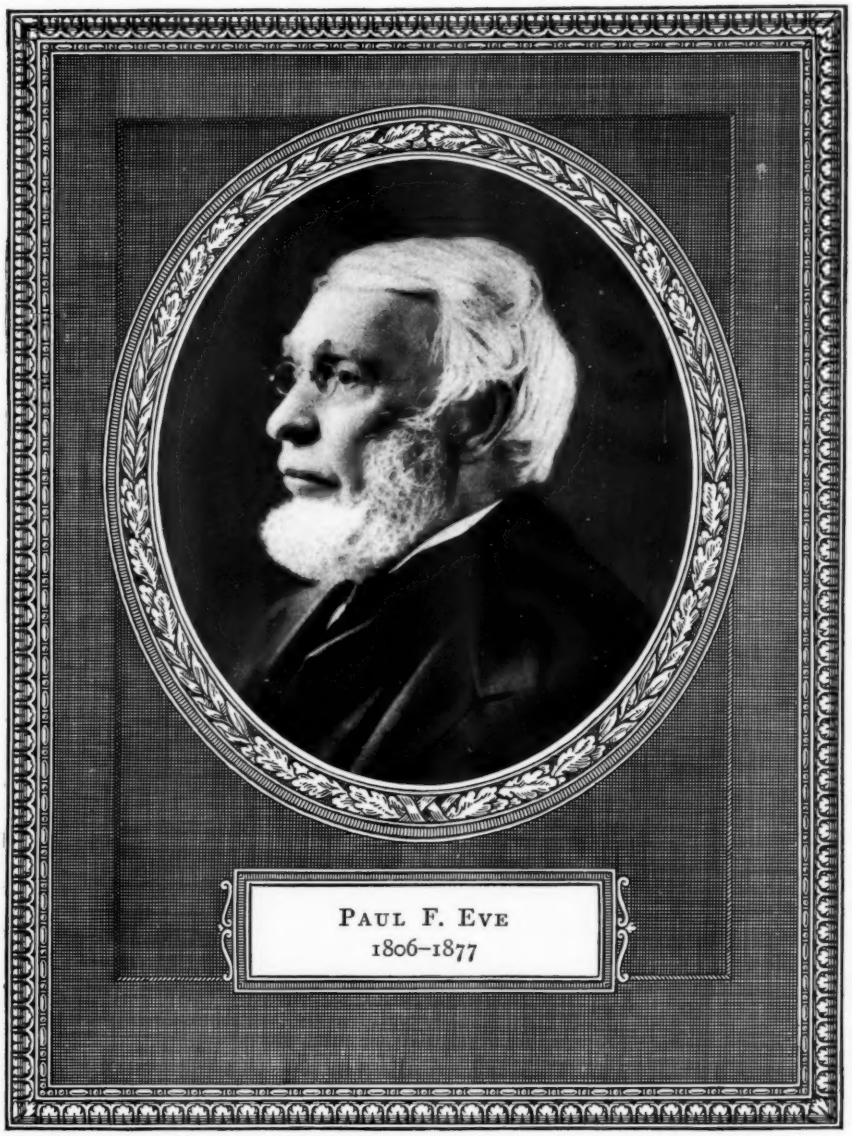
Paul F. Eve graduated from Franklin College, now the literary department of the University of Georgia, in August, 1826, receiving the degree of A. B., and the second honor in a class of twenty-four. This institution later conferred upon him the degrees of A. M. and LL. D. In Philadelphia he commenced the study of medicine as a private pupil of Dr. Charles D. Meigs and graduated in 1828.

His original intention had been to remain in Philadelphia after completing the course of study, and to practice his profession there. He changed his plan because about the time of his graduation his aged father was seriously ill. Returning at once to Georgia, he gave his careful and unremitting attention to his father who died in 1829, and this act of filial devotion shaped his coming life for greatness. He had in the meantime begun the practice of medicine in Augusta, in June, 1828.

Dr. Eve in November, 1829, visited Dublin, Belfast, and London, where he had letters to Sir Ashley Cooper, Abernethy, and others. He reached Paris in February, 1830, and remained there for 18 months, following the course of instruction given by Larrey, Dupuytren, Roux, Lisfranc, Cruveilhier, Trousseau, Récamier, Andrae, Ricord, Louis, and Velpeau, who was used to introduce him as "the tall American surgeon."

Dr. Eve was in Paris in May, 1831, when all Europe was ablaze with turmoil and political excitement. He witnessed the dethronement of Charles X in Paris, and professionally participated in the revolution of the three days (July 27, 28, and 29, 1830). Then he went to Poland and offered his services to that unhappy country in its resistance to Russian oppression. Remembering how the gallant Pulaski had fallen at the siege of Savannah during the Revolutionary struggle of

[1]Adapted from The American Historical Magazine, Oct. 1904.



PAUL F. EVE
1806–1877

UNIV. OF MICH.

1776, he earnestly desired to aid in paying that debt to distressed Poland. He, at length, reached Warsaw and was assigned immediately to hospital service. For his evident ability and his conspicuous devotion to duty, he was soon promoted from the hospital department to be field surgeon of the Fifteenth Regiment of Infantry and Surgeon of Ambulances attached to General Turno's division. The Golden Cross of Honor was also conferred on him on the recommendation of Count Place, chief of the Medical Bureau. During the storming and capture of Warsaw on September 7 and 9, 1831, he was fortunately out of the city on duty. He was subsequently taken prisoner, however, and confined at Werichaw for 30 days, after which he was released under plea of cholera. He reached Paris in October, and there rested and recuperated for several weeks. Sailing from Havre, he reached America after a tedious voyage of 53 days.

In June, 1832, Dr. Eve was elected professor of surgery in the Medical College of Georgia, just then organized in Augusta, and was there engaged in teaching for 17 years, bringing the college great reputation and prestige, and establishing his own fame as a teacher and surgeon.

In 1849 Dr. Eve was chosen professor of surgery in the medical department of the University of Louisville to succeed Dr. Samuel D. Gross, who went to Philadelphia. He delivered one course of lectures in Louisville, but in March, 1850, he resigned and although solicited by the unanimous vote of the trustees, the faculty, and the students to remain, he returned to Augusta.

In 1851 the medical department of the University of Nashville was organized and Dr. Eve accepted the chair of surgery. This he occupied until the fall of Nashville in 1862, and again after the end of the war until 1877, with the exception of 2 years spent in St. Louis where he succeeded Dr. Joseph Nash McDowell in 1868 in the Missouri Medical College.

He could not be contented away from the South, and in 1870 he resigned and returned to Nashville, and lectured to the medical classes of the University of Nashville and of the Vanderbilt University, which then held joint sessions in the same halls. In 1877 he withdrew to aid in the upbuilding of a new school, the Nashville Medical College, afterward the medical department of the University of Tennessee. His death occurred during the beginning of his second course of lectures in this institution.

His success as a teacher and the fame of his teaching may be shown by the records. From the time of its organization in 1832 with 28 students, the Medical College of Georgia increased to 195 students in the session of 1849-50, the last year of Dr. Eve's connection with the institution. This number exceeded the highest ever before or since attained. So in the medical department of the University of Nashville the number of students increased from 136 to 454 for the last session before the war—the largest class then assembled in any medical college in this country outside of New York and Philadelphia.

In 1859 Dr. Eve was on the battlefields of Solferino and Magenta, and communicated to the profession his observations on military surgery through the pages of the *Nashville Medical and Surgical Journal.*

In November, 1861, Dr. Eve was appointed surgeon-general of Tennessee and later chief surgeon of General Joseph E. Johnston's army; he was also president of the Army Medical Board of Examiners. When the fall of Nashville became a certainty, and sudden evacuation was determined upon, he went away leaving everything he possessed. Fort Donelson had fallen. Sunday, February 16, 1862, he left the city at 11 o'clock at night. His family servants went with him although he advised them to remain. Colonel V. K. Stevenson was with him, nearly blind from inflamed eyes. His whole family was out of the city, having gone to Augusta to bury his infant child. By this forced flight he lost all his property. But he went with his own people into exile, his instrument case under his arm almost his sole possession.

After a hurried visit to Augusta to see his family, Dr. Eve returned to Chattanooga and was ordered to organize a hospital service at Atlanta. He remained in charge of the Gate City Hospital there until just before the battle of Shiloh, April 6, 1862, when he was ordered to the front. He did able and valiant service with the army there, and subsequently at Columbus, Mississippi, where he was stationed for several months. Then he was ordered again to Atlanta, thence in 1863 to Augusta, and for a time to Richmond, Virginia. After the surrender, he returned to Nashville.

After the death of his first wife, Dr. Eve married, January 19, 1852, Sarah Ann, daughter of Rev. H. D. Duncan of Barnwell District, South Carolina who survived him nearly 20 years. By his second wife, Dr. Eve had 3 children, Duncan, Sarah, and Paul F. Paul F. Eve, Jr., a surgeon of ability, professor of surgery and dean of the University of Tennessee, died in 1906.

Dr. Duncan Eve, the eldest, born in Augusta, Georgia, May 1, 1853, has been president of the Mississippi Valley Medical Society and first vice president of the American Medical Association, and has been since 1895 professor of surgery in the medical department of Vanderbilt University.

It was in 1873, with all of his family, that Dr. Eve made his seventh and last trip to Europe.

Dr. Eve was one of the editors of the *Southern Medical and Surgical Journal* through the years 1845 to 1849, and was also one of the editors of the *Nashville Journal of Medicine and Surgery* from its establishment in 1851 by Dr. W. K. Bowling, another president of the American Medical Association, to 1873.

He also contributed to Johnson's *Cyclopedia* sketches of distinguished physicians of the South and Southwest to the number of 257, a wonderful accomplishment in itself. His literary work was unremitting and reached the prodigious number of 436 papers, articles, etc., the last of which was an address on the "His-

tory and Achievements of Surgery in the South and Southwest," which he delivered before the International Medical Congress at Philadelphia, on September 6, 1876.

In Nashville in 1857 Dr. Eve was elected president of the American Medical Association. In 1867 he reported to that Association at its annual meeting in San Francisco the synopsis and analysis of 100 cases of lithotomy, performed by the bilateral method. Altogether he performed 238 lithotomies, and had at one operation removed 117 calculi successfully. As a lithotomist he was perhaps without an equal in this or any other country. Of all his bilateral operations for stone in the bladder, only 11 patients died. He published the successful performance of amputations of all classes without losing one case up to the fifty-fourth, the statistics of the major operations comprising 7 of the leg and 7 of the thigh. He reported as "Contributions to the Hip-Joint Operations" 20 amputations, and 18 resections performed in the Confederate service. He reported 3 cases of gunshot wounds, in which the ball lodged in the vertebral column, 2 patients still living, with remarks on "Division of the Spinal Cord without Death." He devised an operation for varicocele, and invented a cannulated needle for applying ligatures and sutures. He was among the first to direct the attention of American surgeons to Esmarch's bloodless method in amputations.

The calculi removed he preserved, and presented to the Medical Museum of the United States Army. The Surgeon-General's office in Washington mounted each set of halves, placing one set in the Museum and returning the other to Dr. Eve. The set belonging to Dr. Eve was kept in the museum of the Nashville Medical College and was destroyed when the building burned. They form in the Medical Museum a collection unequaled in the world as the contribution of a single man.

In Professor Samuel D. Gross's *History of American Medical Literature from 1776 to 1876* he says: "Professor Eve's collection of *Remarkable Cases in Surgery* as a book of reference possesses great value."

When he was in his seventy-first year Dr. Eve wrote that at the University of Georgia, at Athens, where he took a 4 years' course he never missed a recitation. "Took two full courses in the University of Pennsylvania, at Philadelphia, never was tardy once or missed a lecture. While I dare not say that I have done all that I could have done with the means afforded, as a medical professor said in Paris when dying, yet I hope I can truly declare that I have tried to do so. It has ever been with a serious defect in two intellectual faculties, sight and hearing. I was born near-sighted and defective in distinguishing colors. The microscope has even been to me a sealed book; so has auscultation. My hearing is acute, but I never could distinguish one note from another. I know little or nothing of diseases recognized by differences in sounds or colors. What I have done in or for medicine has been with these serious defects."

To regular habits of eating, sleeping, and labor, together with his total abstinence from alcoholic stimulants and tobacco, he attributed much of his good health, health so excellent, indeed, that for nearly half a century he had not lost a day by sickness, and had reached his sixty-eighth year before he felt any influence of age.

Of noble stature and commanding presence, with a splendid head and refined features illumined by the light of genius, Dr. Eve would have been a distinguished type in any group of the most intellectual of his fellowmen. To mental qualifications with which he was plenteously endowed by nature, he added the ripe scholarship of a close student. His most notable characteristic socially was his kindly sympathy and charitable consideration for the younger members of his profession. Dr. Eve was a devoted Christian, and adorned the church as he adorned his profession. This nestor of Southern surgery fell dead between daybreak and sunrise, while hastening to see a patient. He was in his usual health and in full professional panoply when death summoned him November 3, 1877. He fell literally in action, with the harness on and

"Another chief was carried
From life's battle on his spears
To the dim Valhalla cloisters
Of the ever living years."

W. D. HAGGARD

Practica copiosa von dem

Rechten Grundt Deß Bruchschneidens mit sambt dem Figuren darzu dienen etliche Instrumenta vnd Werckzeug Schneiden vnd Bundaryt anfangt mit Grossem Fleiß beschriben Durch Caspar Arnd Bronnigt Schneider vnd Bruchen Arst.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

By ALFRED BROWN, M.D., F.A.C.S., Omaha, Nebraska

CASPAR STROMAYR'S HERNIOTOMY

THE ancient literature on herniotomy is rather hazy and uncertain as to the detailed technique of the operation. Going as far back as Celsus one finds vague statements concerning opening the scrotum, reducing the contents of the sac, and tying it off, and this same indefiniteness and uncertainty persists in nearly all the well-known writers up to the latter part of the sixteenth century. To be sure, different methods are described. Albucasis, as is to be expected, uses the actual cautery and burns the tissues down to the bone. In this method of treatment he follows Avicenna and Rhazes and is in turn followed by Bruno of Longoburgo. Other writers—William of Salicet, Lanfrancus of Milan, and Guy de Chauliac among them—describe dissecting out the hernia, clamping the sac, cord, and all, and removing the entire mass. Still another group advocates the suturing of the neck of the sac with gold wire, the so called "*point doré.*"

It is interesting and noteworthy that none of these writers is at all enthusiastic about the operative treatment of hernia. When it comes to medical treatment and the use of appliances, bandages, and plasters, they give detailed directions as to technique. One cannot help but feel that the actual operative treatment with its attendant, almost universal, castration, did not appeal. Guy de Chauliac states that he does not believe a proper herniotomy can be performed without castration. On the whole they seem to be willing to apply the Hippocratic statement concerning cutting for the stone to herniotomy and let others who are accustomed to it do the operation. With this indifferent attitude existing on the part of the educated members of the surgical profession, it was only natural that a group of lay herniotomists should assume the burden of caring for this condition. If the responsible members let the opportunity slide by because the burden was too great, the irresponsible members were ready and willing to add another surgical procedure to their repertoire. Consequently, herniotomy, lithotomy, and cataract extraction were by mutual consent turned over to the itinerant surgeons, who were poorly educated. In many instances, they were mountebanks and as a rule wholly worthless and irresponsible tramps. The foundation of the Collège de St. Côme and division of surgeons into the classes of those of the long and short robe gave the itinerant surgeon a certain standing and conditions began to improve. Brunschwig and Gerssdorff wrote their works about the beginning of the sixteenth century. The surgeon of the short robe began to study and impart his knowledge to his fellows and operations of election received a certain standing as compared to operations of necessity. Through the efforts of Paré, hernia as well as traumatic conditions received attention and in 1556 Pierre Franco published his first work on this subject. There appeared to be little more than Franco's work for a considerable time, but in 1909 a manuscript was discovered in the City Library of Lindau, Lake Constance, which deals largely with the subject of hernia. This has been beautifully reproduced, explanatory historical notes have been added by Dr. Med. Walter von Brunn, Professor of Medical History at the University of Rostock, and the book has been published by Idra-Verlaganstalt G. m. b. H., of Berlin.

The manuscript was written and the figures were probably painted by one Caspar Stromayr of the town of Lindau in Lake Constance. The volume is dated July 4, 1559. It is dedicated to Petter Hafner, who is described as wound, cutting, and eye physician of Zurich. This gives the only point of contact between Stromayr and the medical profession, for this Petter Hafner married Anna Ruff, the daughter of Jacob Ruff, or Rueff, who wrote the famous "Schoen Lustige Trostbuechle" on obstetrics. Beyond this nothing is known of Stromayr or of his life. He must have been a lay surgeon, for his work shows a knowledge which would have given him a standing among the well-known surgeons of the world had he been a member of the regular profession. Moreover, in his introduction to the reader, Stromayr stresses the knowledge of the actual condition and the dexterity of the surgeon and deprecates the possession of letters of recommendation, and seals, and a knowledge of Latin as criteria of ability. In fact he gives the impression that his opinion of the so-called educated physician was not particularly high so far as operative surgery is concerned. He shows interesting colored sketches of various types of hernia and of the operative procedures which he recommends. He does not perform castration and his operation is much like that of Franco.

The point to wonder at is that such a manuscript as this should have lain hidden for three and a half centuries.

A REVIEW OF NEW BOOKS ON GYNECOLOGY AND OBSTETRICS

By GEORGE GELLHORN, M.D., F.A.C.S., St. Louis, Missouri

WITH the sanction of the Editor, I place at the head of the list a book[1] that is neither gynecological nor even intended for medical men. Its author has previously published an extensive textbook on therapeutics which it was my privilege to review in these columns a few years ago. What attracted me in that book was not only the crystalline clarity of the presentation and the breadth of knowledge but also the style, so beautiful as to be almost unique in medical literature. The author presented facts in such a way as to make them alluringly interesting. Furthermore, the volume was permeated with golden rays of a pithy humor which rendered study a keen enjoyment.

These same features characterize the present volume which the author has intended for the use of the laity. The desire to know something about the body in health and disease, is a sign of our times, and if gratified and led into proper channels, it is, perhaps, the best safeguard against the dangers of half-baked fads and fraudulent cults. In essence, the book provides a sound foundation of normal and pathological physiology; and when the lay reader has once acquired this knowledge, he is bound to appreciate better, and co-operate more fully with, the efforts of his medical adviser.

The author divides his subject into four parts, entitled, respectively, "The Human Body as a Unit," "The Human Body as an Organism for the Conversion of Food and Air into Energy and into Tissue," "The Human Body as an Organism for the Reproduction of Its Own Kind," and "The Human Body and Disease," and in each of these parts, the functions of the various tissues and organs, their alteration by disease, their interrelation in the body, etc., are explained in sub-chapters. This list of contents may appear rather too formidable for the average lay reader; yet, the author accomplishes his task in an altogether admirable manner, never talking down to his audience though he has frequent recourse to familiar similes or experiences, but lifting them up by means of his wonderful diction to a higher level where the blank ignorance and grostesque misapprehensions of former days are banished and where mankind may more fully enjoy the fruition of a progressing civilization.

Now, I do not believe in the millennium, but I believe that those who come under the spell of this book, will be better and wiser men and will enjoy their lives more fully. They will chuckle at the gems of humor which sparkle through the pages, even as I have done as I read the volume from cover to cover. Their eyes will also be opened to the "medical follies" that beset us on all sides, whether they appear in the garb of so-called regular medicine or as thinly disguised frauds.

Let me give you a few selections for your delectation. "If you follow very carefully the dictates of the Life Extension Institute, you can live on the average one month longer than you would otherwise, which period you will spend in bed flat on your back, giving explicit instruction to the nurse as to whom you want for pall-bearers." Speaking of renal colic, "childbirth is usually set up as the universal standard of pain; I gather from careful research that an ordinary kidney-stone colic is equal to two childbirths and a miscarriage." Who would not agree with this estimate of the literature on the endocrines? "Much of this, both that intended for physicians and that intended for laymen, is put forward with the solemn appearance of fact. Actually, it is pure arm-chair speculation." And of migraine, "like mercy, or the fruits of science, it falleth upon the just and the unjust. . .There is only one way to treat it—with contempt, an old Roman remedy. Resignation is a good adjunct, now little used in the treatment of disease."

There is a more positive tenor in his reference to the Rockefeller Foundation, the McCormick Institute, and similar endowments; and his advice to his lay readers, some of whom may have funds which they would like to use for the benefit of their fellow human beings, is that there is no way to use them more effectively than by the endowment of medical research.

There is, to me, in this book a significance beyond its value to the laity. Think of most of our textbooks. How dry they are, how difficult to plod through! Why must the acquisition of knowledge be made so hard? Here is a textbook on physiology in all its aspects, of less than 400 pages, including more than a hundred instructive pictures, written as fascinatingly as the subject itself is fascinating; and, in truth, if the average medical student knew only as much of the matter as is contained in this book, he would know a lot more than he actually carries from school into practice.

TO the thousands of American gynecologists who have not yet had access to radium and acquired sufficient personal experience, the book by Clark and Norris[2] will be a most welcome message. As far as I know, it is the first attempt in this country to present the question of radium in gynecology in monographic form. We are introduced to the subject by a truly excellent chapter on the physics of radium from the pen of Gioacchino Failla, physicist to the Memorial Hospital in New

[1] The Human Body. By Logan Clendening, M.D. New York and London: Alfred A. Knopf, 1927.

[2] Radium in Gynecology. By John G. Clark, M.D., and Charles C. Norris, M.D. Philadelphia and London: J. B. Lippincott Co., 1927.

York. Here the complicated physicochemical problems involved are cleared up for us as if by a magic wand, and we are made to understand the intricate nature of the interaction between matter and radiation, of ionization and other scientific factors which underlie the administration of radioactive agents, such as filtration and the ratio of susceptibility of different tissues.

Clark and Norris now take up the story and tell us, in the following chapter, their clinical observations on the variations in susceptibility of different tissues. They stress the importance of teamwork between surgeon, pathologist, and physicist for successful radiotherapy and insist on exploratory excision of tissue not only for the purpose of making an exact diagnosis at the earliest possible moment, but also because the degree of maturity of the cancer cells will affect the method of treatment. The danger of rapid dissemination following diagnostic excision or curettage appears, to the authors, less important than the advantages gained.

Quite naturally, the greatest emphasis is laid on the use of radium in cancer, and there follow four chapters in which malignant tumors of the vulva, vagina, cervix and body of the uterus are discussed and valuable technical points are presented. Of particular interest is the authors' own method of cautery amputation followed by irradiation. Their results are encouraging and should prove highly stimulating to American gynecologists.

As to fibroids, the authors take a standpoint very similar to the one taken by the reviewer some years ago. In the question of cervicitis, they have followed the lead of Curtis with pleasing results, and their experience with membranous dysmenorrhœa proves that this disease is, after all, not intractable. We may, finally, mention the chapter dealing with pseudomyxoma peritonei, granuloma inguinale, malignant ovarian tumors, sterility and dysmenorrhœa to indicate the wide scope covered in this monograph.

To us who have known and loved John Clark, it is a matter of sad regret that he did not live to see his book in print, but he has left the work in the capable hands of his co-worker Norris, who has given a work of definite practical value not only to the gynecologist but also the general practitioner who may read therein how much can be accomplished with radium in gynecology.

THE socialization of medicine has progressed in Germany much farther than in other countries. For the past seven years, graduate courses have been given in several German universities where federal, state, or local health officers, school and factory physicians, doctors attached to the courts, police prisons or sick benefit lodges, etc., attend lectures on the various branches of medicine. The small book before us, entitled Social Obstetrics and Gynecology,[1] is the crystallization of one of these courses. The author is internationally known as one of the path-finders in gynecological physiology and has, on his recent visit to the United States, made many personal friends. He desires to give his readers guide lines in their official sphere of action as far as gynecology and obstetrics are concerned. The headings of some of the chapters will explain the scope of the work: Regulations regarding the hygiene of the newborn; the girl at school age; dress of child and woman; physical exercises for women and children; determination of virginity and motherhood; rape; legal determination of sex; criminality in women; general sexual hygiene; marriage; prenatal and postnatal care; social insurance; instruction of midwives; industrial diseases of women; police supervision of prostitutes, etc. All these subjects are discussed briefly and with reference to existing laws and ordinances. Some of these are, of course, specifically German and have no counterpart in our own legislation. A surprisingly large part of the book, however, applies to conditions in our country as well; and as thus far very little attention has been given to the *social* pathology of diseases of women in our textbooks, the American reader will find the study of this unpretentious volume extremely stimulating. He will also appreciate the simple and direct style which greatly facilitates the perusal of a book in a foreign language.

[1] SOZIALE GEBURTSHILFE UND GYNAEKOLOGIE. By Prof. Dr. L. Fraenkel. Berlin and Vienna: Urban & Schwarzenberg, 1928.

IN the six years which have elapsed since the first edition of Young's Gynecology appeared, quite a few advances in our knowledge have necessitated a re-writing of parts of the book. Thus we find in the new edition[2] a discussion of the Rubin method, the cyclic changes in the ovary and their bearing on menstruation, the curative value of radium, the endometrial transplants of Sampson, and other subjects. A volume of only a little more than 300 pages might well appeal to the student. A future edition might be made still more attractive by deleting certain obsolete matters or modifying statements such as the assertion that gonorrhœa can be cured "by three or four douches daily of potassium permanganate 1:8000." In favor of the book, and of prime importance to the student who is being initiated into this field, is the wholesome emphasis which is laid on pathology and diagnosis; and the differential diagnosis, too, for instance in uterine cancer or tumors of the ovary, has distinct merit.

THERE is no such thing as a sexually frigid woman—that is the *leitmotif* of Steckel's extensive work[3] on anaphrodisia in women. Passion may be hidden, inhibited, repressed, or transposed into other channels, but it is never wholly absent. In these days, the art of loving is on the decline.

[2] A TEXTBOOK OF GYNECOLOGY. By James Young, D.S.O., M.D., F.R.C.S. (Edin.). 2d ed. New York: The Macmillan Company, 1927.

[3] DIE GESCHLECHTSKAELTE DER FRAU (EINE PSYCHOPATHOLOGIE DES WEIBLICHEN LIEBESLEBENS). By Dr. Wilhelm Steckel. Berlin and Vienna: Urban & Schwarzenberg, 1927.

"The most marked evidences of this fact may be observed in America where the man is so busy with money-getting that love is relegated to a second place. In America, too, so-called sexual anæsthesia is very common among women. Yet, the hypocrisy of the New World is well known: an exaggerated prudishness on the surface, and underneath indulgence in the wildest passions in such unheard-of forms as orgies with Negroes and Chinese."

This quotation, which proves the danger of generalization from sporadic instances of sexual depravity, will show the American reader that not every statement in this book can be accepted at face value. But it would be wrong to condemn the whole work because of a few exaggerations or misstatements. On the contrary, we have every reason for learning something about the psychic phenomena in our patients; and in the question of dyspareunia, in particular, every careful observer will admit that mechanistic explanations, the only ones which are discussed in our gynecological textbooks, are not sufficient in all cases. I dare say that we are already receding from a too one-sided standpoint, and that suggestions for curing masturbation or frigidity by excision or some other operation on the clitoris, which formerly seemed quite legitimate, nowadays appear to us ridiculous and mediæval.

It seems to me that Steckel, who is a prominent psychoanalyst in Vienna, goes to the other extreme, that is, he explains most gynecological diseases and practically all disturbances of the sexual life by psychological factors. We must, however, concede that he offers plausible solutions of a good many problems that have heretofore baffled us. There is, for instance, the oft-made observation of husband and wife who have lived in sterile wedlock for years, and after divorce each beget children in a second marriage (p. 320). There is the question of effluvium seminis (p. 112), of painful cohabitation in the absence of tangible causes (p. 197), of the psychic etiology of certain forms of vaginal discharge (p. 522), or of imaginary pregnancy (p. 530), and others too numerous to mention here. To offset this, we are stirred out of our unreserved acceptance of the author's views by a sentence such as this: "To be raped by her own father has been the wish or dream of, perhaps, every girl at one time or other in her life."

The study of this book, therefore, requires a good deal of critical judgment, and only with this proviso might the microscopy of the soul, as expounded by the author, be made useful for the diagnosis and treatment of some of our gynecological problems.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

PETITE CHIRURGIE. By J. Maisonnet. Paris: Gaston Doin et Cie, 1928.

TRAVAUX DE LA CLINIQUE CHIRURGICALE ET DU CENTRE ANTICANCÉREUX DE LA SALPÊTRIÈRE. By A. Gosset. 2d Series. Paris: Masson et Cie, 1927.

METHODS AND PROBLEMS OF MEDICAL EDUCATION. 8th series. Division of Medical Education. New York: The Rockefeller Foundation, 1927.

THE CURRENT SIGNIFICANCE OF THE WORLD "ALUM." William D. Richardson. Chicago: The Commonwealth Press, 1927.

LA RADIOGRAPHIE; EN GYNÉCOLOGIE, EN OBSTÉTRIQUE ET EN UROLOGIE. By Dr. Carlos Heuser. Buénos Ayres, 1926.

THE HISTORY OF BRITISH MIDWIFERY FROM 1650 TO 1800; THE FITZ-PATRICK LECTURES FOR 1927 DELIVERED BEFORE THE ROYAL COLLEGE OF PHYSICIANS OF LONDON. By Herbert R. Spencer, M.D., B.S. Lond. London: John Bale, Sons & Danielsson, Ltd., 1927.

EXPOSURES OF LONG BONES AND OTHER SURGICAL METHODS. By Arnold K. Henry, M.B., B.Ch. (Univ. Dublin), F.R.C.S.I. Foreword by Sir W. I de C. Wheeler (Dublin). New York: William Wood and Company, 1927.

CANCER D'ESTOMAC. By Victor Pauchet and A. HIRCHBERG. Paris: Gaston Doin et Cie, 1928.

INTERNATIONAL CLINICS; A QUARTERLY OF ILLUSTRATED CLINICAL LECTURES AND ESPECIALLY PREPARED ORIGINAL ARTICLES ON TREATMENT, MEDICINE, SURGERY, ETC. Edited by Henry W. Cattell, A.M., M.D., with the collaboration of others. Vol. iv, 37th series, 1927. Philadelphia and London: J. B. Lippincott Company, 1927.

DER KREISZENDE UTERUS IN OPERATIONS-ANATOMISCHER DARSTELLUNG. ZUGLEICH ERGAENZUNGSBAND ZUM ATLAS DER OPERATIONS-ANATOMIE UND OPERATIONS-PATHOLOGIE DER WEIBLICHEN SEXUALORGANE. By Dr. Wilhelm Liepmann. 2d ed. Berlin and Wien: Urban & Schwarzenberg, 1927.

PYELOGRAPHY; ITS HISTORY, TECHNIQUE, USES, AND DANGERS. By Alex. E. Roche, M.A., M.D., M.Ch. (Camb.), F.R.C.S.(Eng.) With an Introduction by Sir John Thomson-Walker, O.B.E., M.B., C.M., F.R.C.S. New York: William Wood & Company, 1927.

ANNUAL REPORT OF THE SURGEON GENERAL OF THE PUBLIC HEALTH SERVICE OF THE UNITED STATES FOR THE FISCAL YEAR 1927. Washington: United States Government Printing Office, 1927.

GYNECOLOGY FOR NURSES. By Harry Sturgeon Crossen, M.D., F.A.C.S. St. Louis: The C. V. Mosby Company, 1927.

CHIRURGIE DE REIN. By Dr. Edmond Papin. Vols. i and ii. Paris: Gaston Doin et Cie, 1928.

L'ANNÉE OBSTÉTRICALE; TRAVAUX DE 1925 ET QUESTIONS OBSTÉTRICALES D'ACTUALITÉ. By H. Vignes and B. Jean. Paris: Masson et Cie, 1927.

MAX VON PETTENKOFER; HIS THEORY OF THE ETIOLOGY OF CHOLERA, TYPHOID FEVER, AND OTHER INTESTINAL DISEASES; A REVIEW OF HIS ARGUMENTS AND EVIDENCE. By Edgar Erskine Hume, M.D., Dr. P.H., LL.D. New York: Paul B. Hoeber, 1927.

THE EXTRA-OCULAR MUSCLES; A CLINICAL STUDY OF NORMAL AND ABNORMAL OCULAR MOTILITY. By Luther C. Peter, A.M., M.D., Sc.D. Philadelphia: Lea & Febiger, 1927.

THE PREVENTION OF ORTHOPEDIC DEFECTS, WITH SPECIAL REFERENCE TO THE SPINE AND THE FEET. By S. C. Woldenberg, B.Sc., M.D., M.Sc. St. Paul; Bruce Publishing Company, 1927.